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AROMATIC OR ORIENTAL TOBACCOS

AROMATIC OR ORIENTAL TOBACCOS

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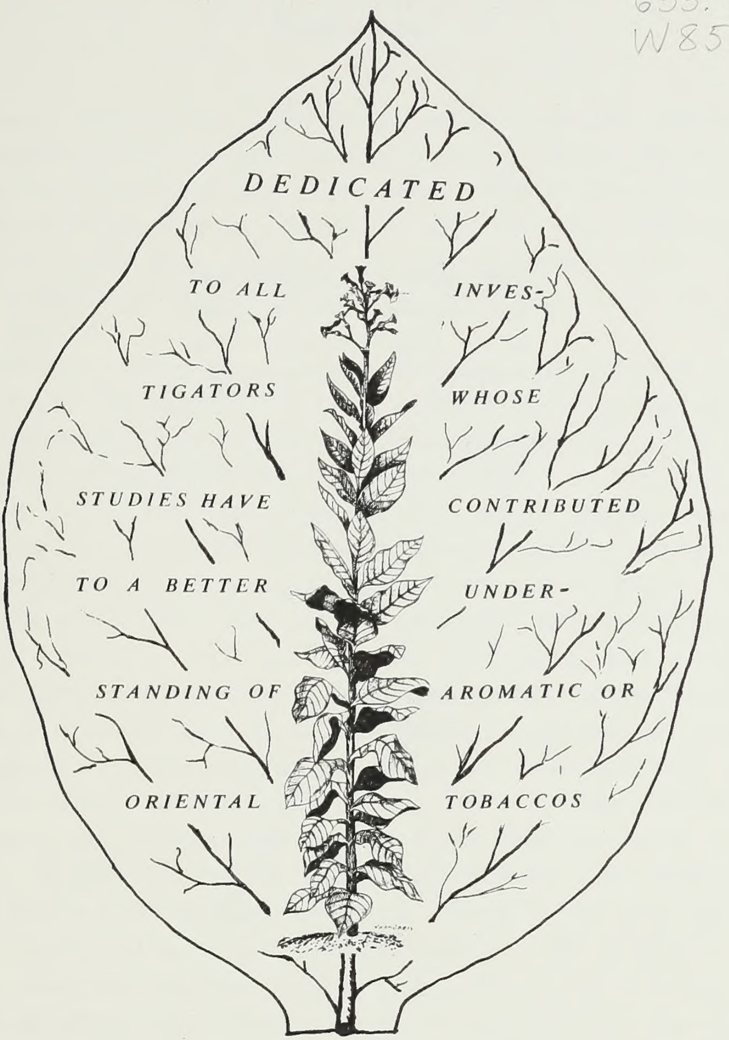

DEDICATED

TO ALL INVESTIGATORS WHOSE
STUDIES HAVE CONTRIBUTED
TO A BETTER UNDERSTANDING OF AROMATIC OR
ORIENTAL TOBACCOS

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Foreword

Tobacco is among the cultivated plants of world-wide distribution. The tobaccos grown in different regions, however, are of different kinds or types. Until the beginning of the present century the production of tobaccos of a type variously known as aromatic, oriental, Levantine, Turkish, or Greek was restricted to the Eastern Mediterranean region, an area comprising southeastern Europe, Asia Minor, and contiguous western Asia.

The writer and his associates, on first becoming interested in aromatic tobacco, encountered the belief generally accepted among competent, well-trained tobacconists, that aromatic tobaccos can be grown nowhere else in the world except in the Near East. Such persons were convinced that (1) aromatic tobaccos are entirely different from all other types; (2) the production of such tobaccos requires peculiar skills and practices that are enshrouded with secrecy and are known only to inhabitants of the Near East; (3) experiments have established that failure to produce a satisfactory product will always occur whenever aromatic tobaccos are planted in any region apart from the Near East; (4) seed of aromatic tobacco, even if planted in soil shipped from the Near East to any other region, will always fail to produce leaf having the characteristics of aromatic tobaccos. In fact, these beliefs were employed as propaganda, and to substantiate them the results of trial plantings in different regions of the United States were cited which showed that in some instances thousands of dollars had been expended in unsuccessful efforts to grow aromatic tobacco. To us, however, the evidence that such tobaccos could be grown only in the Near East was not entirely convincing. Even a perusal of available literature did not reveal how and why aromatic tobaccos differ from all other kinds or provide any knowledgeable basis to account for characteristic traits of this type of tobacco.

Beginning in 1939, at Duke University, it was decided to make a study of aromatic tobaccos in efforts to learn something of the conditions required for the cultivation of this crop and to gain some knowledge of the origin, morphology, and physiology of aromatic tobaccos, and of the chemical composition of the cured leaf in comparison with that of other types of tobaccos. These studies have been continued up to the present. Valuable co-operation throughout the years has been provided by members of the staff of the Tobacco Research Station, Oxford, North Carolina, and that of Chatham, Virginia, and also that of the South Carolina Agricultural Experiment Station, Clemson, South Carolina. For this co-operation I am glad to extend my deepest appreciation and sincerest thanks.

This volume is intended to serve as a general agricultural treatise on aromatic or oriental tobacco, since no book on this subject, written in English, exists. It contains an account of our investigations over a twenty-year period. In addition, much information has been acquired from other sources, especially from publications from countries in the Near East and from personal observations made during a visit to Turkey, Greece, and Italy. Very limited ability to read the languages of the peoples in southeastern Europe and in Asia Minor has constituted a serious handicap. Certainly a familiarity with these languages would have made possible the preparation of a more comprehensive and more useful volume. Doubtless much of value has been overlooked about oriental tobacco that is contained in publications such as the following ones: (1) from Russia, the bulletins from the Krasnodar Vsesoiuznyi Nauchno Issledovatel'skii Institut Tabachnoi I Machorchnoi Promyslennosti; also reports in *Tabak* (2) from Turkey, *Tekel Enstitüleri Rapporlari;* and the reports of the Tekel (Monopoly) which this series superseded; (3) from Bulgaria, *Bulgar. Tiutiun;* (4) from Rumania, *Buletinul Cultivarii si Fermentarii Tutun, Bucureşti;* (5) from Yugoslavia, the Serbo-Croatian *Duvan;* (6) from Italy, *Real Instituto Sperimentali par la Coltivazioni del Tabacchi. Scafati (Salerno)* and *Il Tabacco;* and from Greece reports from the Tobacco Institute of Greece, Drama. Additionally much valuable information is contained in the scientific journals of the countries of the Near East.

It is well known that for a period of approximately three hundred years, empirical procedures, learned from experiences in growing and handling aromatic tobaccos, have been followed in certain of the countries bordering the Mediterranean, Aegean, and Black Seas. In none of these countries, however, except the U.S.S.R., until the beginning of the present century, did agricultural scientists concern themselves with problems of tobacco production as they relate to suitable soils, improved varieties, and the chemical composition of the cured tobaccos. In Greece and Turkey scientific practices in producing and manipulating tobacco were first employed about 1930. Then experimental stations, having comprehensive programs of agronomic investigations, were organized. As a result improvements have been made in farm practices, superior varieties have been developed and are being grown, diseases and pests are being controlled to a degree, and better procedures are being employed in sorting, baling, manipulating, storing, and fermenting the cured leaf. Efforts have also been made to improve the economic status and the welfare of growers and of those employed in the storage depots.

It is hoped that the information assembled in this book will be of value to all who are interested in any phase of the aromatic tobacco industry. It should not fail to leave the impression, however, that much remains to be learned by agronomists, biologists, botanists, chemists, economists, entomologists, engineers, geneticists, physiologists, pharmacologists, plant pathologists, and physicists or other scientists who have devoted themselves to investigations of aromatic tobaccos. It is to be hoped they will continue to do so. Such scientists, each in his own sphere of interest, by continuing their researches will be able to contribute materially to our present body of knowledge of the industry.

Evidence will be marshaled herein to show that all types of tobacco have the same origin, an opinion that has been maintained by botanists and geneticists generally, a fact that is basic and also one that has far-reaching implications. Morphology of the leaves will be correlated with quality, a characteristic that cannot be clearly defined or appreciated even by the person with experience in handling tobacco. Aroma will be traced primarily to the secretions or exudations from glandular hairs. Chemical differences among leaves on the same plant will be traced to differences in the stalk position at which they were borne and to compensatory responses among leaves to physiological imbalance induced by priming. Effects of spacing, of availability of nutritional minerals, and of climatic factors will be given consideration as they bear on quality of the crop.

The production of quality in aromatic tobacco will be shown to be traceable primarily to edaphic and climatic factors, and to cultural practices, and consequently geneticists are quite unable to do anything to modify, change, or stabilize quality of the cured leaf. It will be maintained that there is no particular virtue in exposing aromatic tobacco to direct sunshine during curing. Sunlight modifies the relative humidity of the air and in so doing promotes drying. But by using artificial heat, relative humidity can be controlled to the extent that an excellently cured product may be obtained in the complete absence of exposure of the curing leaves to direct sunshine. Mechanization in planting, harvesting, curing, and sorting will be suggested or indicated as means of making the production of aromatic tobacco more profitable not only in the Near East but also in regions where labor is less abundantly available and labor costs are higher. As a result of mechanization, of increase in population, of economic pressures, and of increase in demand for aromatic kinds of tobacco, the production of this crop in regions other than the Near East, no doubt, will be increased. So far as possible the science and art of growing, curing, and manipulating aromatic tobaccos will be correlated and specific procedural directions will be outlined to guide persons in growing and handling this crop.

The proper spelling of names of places and of tobacco varieties has been a matter of concern to me. Cartographers are not in accord on the spelling of place names, because it is not always possible to use the English alphabet and approximate the sounds of words used by the peoples of the Near East. These orthographic difficulties are therefore the source of inconsistencies. It is hoped that the reader will not be confused to find several spellings of the same word herein since it is spelled differently in different countries and that he will be inclined to be charitable in criticisms about proper spelling of names.

Also the reader may elect to interpret differently some of the data included herein, a privilege that has always been exercised among scientists. Each one of us has a different background of training and experience, hence has a different point of view as to the meanings of a body of data. The writer must accept full responsibility for his own interpretations of these data and for any conclusions drawn from them even though they may be deemed by others to lack adequate support. The reader will find, no doubt, that certain data warrant the drawing of additional conclusions. The most meritorious criticism and evaluation of any research, specifically of the writer's interpretations of researches pertaining to aromatic tobaccos, noted in the present volume, will continue to be not those expressed in a casual manner by persons with different opinions but by those with sufficient conviction to publish their own interpretations and criticisms. The best criticism is to write and publish a better product.

One may not elect to consult the various chapters in sequence, as arranged. It will be found that there is a measure of repetition among the chapters, but repetition could not have been avoided completely, regardless of the arrangement of chapters. It is hoped that this will not confuse the non-technical reader or irritate the highly trained technician. Repetition appears to be unavoidable, partly because of overlapping of subject matter in the chapters and partly as a result of efforts to make each chapter a well-rounded entity.

Finally, I am beholden to many persons who have helped me in every possible way during my researches and during the preparation of this volume. I hereby express my heartfelt gratitude to each of them. Economy of space demands that I forego the pleasure of specifying the kind of aid given by each of these persons for which reason I shall merely list their names and addresses.

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The explanatory legends that accompany the graphs, drawings, and photographs are deemed to be adequate. With few exceptions, therefore, further explanation is omitted in the text. The source of all of the illustrations, except those made by Mr. J. R. Riddick and me or by me alone, are noted in the legends. Mr. Riddick shares credit for Figures 48, 58, 59, 60, 64, 65, 68, 75, 80, 81, 82, 84, 106, 111, 115.

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AROMATIC OR ORIENTAL TOBACCOS

Chapter One

HISTORICAL INTRODUCTION

Tobacco is universally regarded as among our most important crop plants. Certainly no other crop has exerted so profound an influence upon the political, economic, social, and religious life of all nations and peoples that have been concerned with its production, commerce, manufacture, and use. Regardless of one's personal opinion or bias as to whether this influence on the whole or in part has been or is beneficial or harmful, it must be admitted, as pointed out by Brooks (Arents, 1937), that "tobacco serves as a means of satisfying one of the most social of man's customs and habits. For this reason alone, even if there were no other, the plant will remain throughout the foreseeable future an essential adjunct to our way of life."

Tobacco belongs to the genus *Nicotiana* in which are grouped approximately sixty species. Two of these species, *N. tabacum* L. and *N. rustica* L. are widely cultivated. The former is the ordinary tobacco of commerce although the latter is also grown extensively in western Asia, where it is known among the Russians as *makhorka,* and among the Arabians as *tombac (tönbeki).* Several distinct types have been developed within each of these two species. The most important ones derived from *N. tabacum* and grown in the New World are the following: (1) cigar tobaccos, including wrapper, binder, and filler; (2) Virginia, or flue-cured; (3) Burley; (4) Maryland; (5) dark fire-cured; (6) dark air-cured; (7) perique; and (8) aromatic or oriental. Similar types or their counterparts, as Bidi tobacco grown in India, and Latakia, a fire-cured aromatic tobacco from Cyprus, are grown in the Old World. Within each of these types there are several to many agronomic kinds or varieties. Producers and tobacconists are able to identify many of them, not only while the crop is growing in the field, but, more remarkably, from examination of the cured leaf.

Much has been written that deals with the historical aspects of every phase of the tobacco industry, but no one appears to have limited his account to aromatic tobaccos alone. This is due to the fact that every phase of the entire industry as it involves any given type is intricately interrelated with and dependent upon that of every other type of tobacco. Therefore to understand better such matters as the origin, morphology, physiology, genetics, diseases and pests, curing, fermentation, or other aspects of aromatic tobacco, a brief historical background of tobacco in general will first be given.

By consulting Arents' (1937, 1938, 1940, 1943) five-volume history of tobacco and the supplements by Dickson (1958) one is made to realize that a wealth of published material exists dealing with this crop and the place that tobacco and its products have come to occupy in man's multifarious activities. In *The Mighty Leaf*, Brooks (1952) interpreted his researches made during the course of preparing Arents' volumes, and stated in the foreword "Everything that seemed of interest and importance in the history of tobacco is brought together in this volume." Its contents include such materials as (1) the ritualistic, medicinal, and sacerdotal uses of tobacco by the Indians; (2) the adoption with avidity of the habit of smoking by Europeans and Asiatics with resultant legal, social, and religious consequences, (3) the struggles that arose as a result of the use of tobacco and criticisms that were leveled against tobacco by governmental leaders and the clergy through-

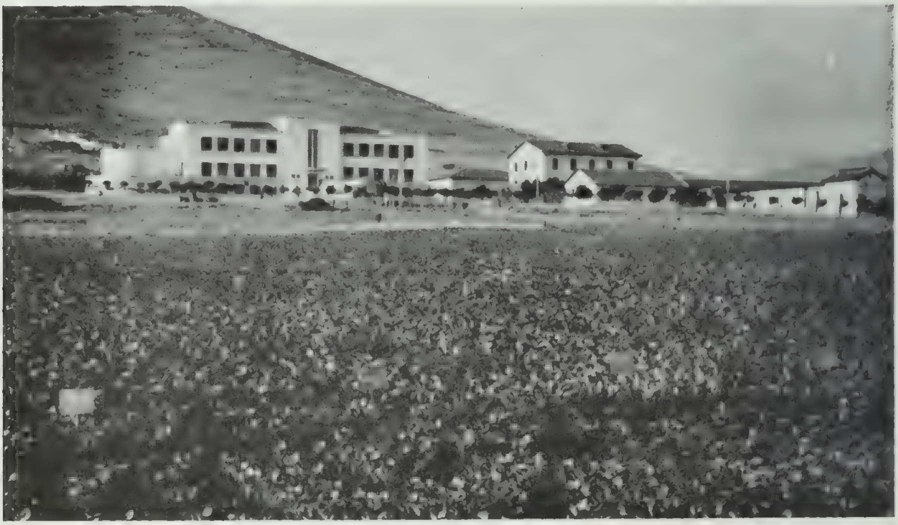

FIG. 1. Tobacco Research Institute of Greece at Drama. Experimental plots in the foreground, laboratories and offices in the building at left, in front of which are the greenhouses. At right, curing barns and buildings equipped for sorting, baling, and storage. Courtesy D. Arghyroudis.

out Europe and Asia, and the persecutions that followed; (4) the exploitation of claims that tobacco possesses a variety of medicinal and therapeutic values; (5) the development of an agricultural economy among our American colonists that was based upon the cultivation and exportation of tobacco; (6) the development of systems of taxation of tobacco and its products and the resultant effects upon the exchequers of various European, Asian, and North American countries; (7) the use of tobacco as legal tender in the American colonies, even to the extent of being bartered for brides; (8) the changes in sentiment about the use of tobacco, and acceptance by the public of changes in taste from pipes to snuff to cigars to cigarettes; (9) the technological developments, including mechanical, chemical, and biological ones, that have been made and their modificatory influence upon tobacco production, marketing, storage, manufacture, and commerce.

The history of tobacco properly begins with the discovery of the New World in 1492 by Christopher Columbus. He and his sailors observed that the Arawak Indians on the island of Guanahani (San Salvador) and other West Indian islands burned the leaves of a certain plant in a tube and inhaled the smoke through their nostrils. In due time this plant came to be known as tobacco. Explorers reported that the Aztecs in Mexico and Central America called the plant *yetl,* the Indians of Brazil, *petum,* and those of the West Indies, *yoli.*

Some historians have maintained that smoking was a custom practiced by the Chinese and Mongolians long before the discovery of America. Such writers point to the probability that the American Indians originated in Asia, migrated to North America across an Alaskan land bridge that disappeared during the Ice Ages, and thence they came to South America, taking seed of tobacco with them. However, none of the early travelers in Asia, among whom Marco Polo is perhaps the best known, mentioned tobacco. In 1269 his travels extended through Armenia, Persia, India, China, and Mongolia. It may reasonably be assumed that he would have mentioned tobacco had it been used in these countries, since he reported that the Tartars drank fermented milk, the Arabs, palm wine, and that betel nuts were chewed by inhabitants of India. These habits were noted also by John Moundeville, who, in 1507, traveled throughout Armenia, Persia, Arabia, India, Ceylon, Sumatra, China, and Egypt.

History records that the ancient Egyptians, as a sacerdotal rite, burned incense. This ritual could have spread to Asia Minor and to

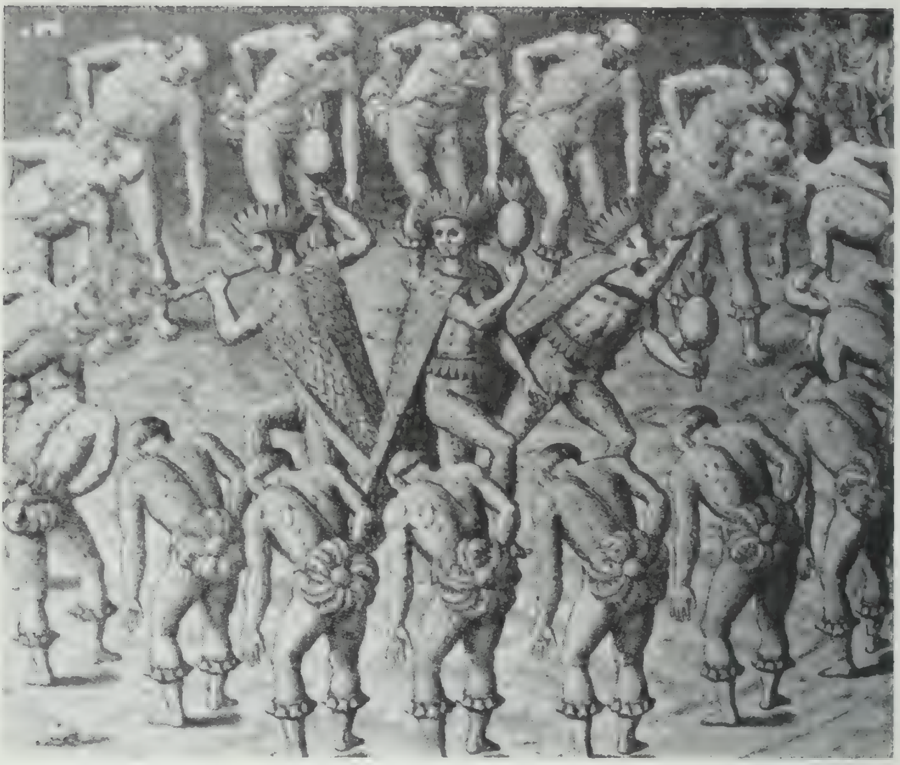

FIG. 2. This engraving from *Americae Tertia Pars* by Jean de Léry is the earliest known illustration depicting a tobacco ritual. Carib warriors of Brazil are shown, dancing about their priests, who blow smoke upon them and exhort them to fortitude. The volume was published by Theodore de Bry at Frankfort-on-the-Main, in 1592.

other Mediterranean regions. But, as pointed out in the first volume by Arents (1937), tobacco used as incense or in any other way is not alluded to in the Koran, in the old writings of the Egyptians, Hebrews, and Chaldeans, or in any Sanskrit works. Such lack of mention of tobacco would be entirely contrary to expectation had the plant been native to Asia or Africa. The researches of Brooks (1952) on this point led him to conclude that "The factual evidence from botany, archeology, anthropology, linguistics, and the records of antiquity all lead to the inescapable conclusion: tobacco is as American as the Indians who presented it to the rest of the world."

In efforts to determine their origin, many years have been devoted by Setchell (1921) and Goodspeed (1954) to collecting and studying the species of *Nicotiana* found in the western United States, Mexico, Central America, and South America. They note that *N. rustica* was under cultivation in Mexico in pre-Columbian times and is native to the highlands of Bolivia, Peru, and Ecuador. *N. tabacum* shows a blending of characters of *N. sylvestris* Spegazzini & Comes and members of the section Tomentosae, as regards general habit, leaf shape and size, expansion of the throat of the corolla, and types of trichomes.

Goodspeed (1954) noted that both *N. sylvestris* and *N. otophora* Griesebach presently are found in northwestern Argentina and adjacent Bolivia. Evidence indicates that in this region these two may have hybridized naturally to give rise to *N. tabacum.* He also noted that *N. tabacum* often occurs as an escape, especially in the Andean portion of Brazil and contiguous Peru and Ecuador.

According to Goodspeed (1954), thirty-six of the sixty recognized species of *Nicotiana* are indigenous to South America, nine to North America, and fifteen to Australia and islands of the South Pacific in the vicinity of Australia. By the time that the white man came to the Americas, the Indians, using tobacco in religious and social ceremonies, had already spread *N. tabacum* throughout Brazil, Colombia, Venezuela, Central America, Mexico, and the West Indies. They had also widely dispersed *N. rustica* and it was being smoked and chewed by Indians living east of the Mississippi River. The Indians of the western United States long used certain of the indigenous species of *Nicotiana,* such as *N. bigelovii* (Torrey) Watson, *N. attenuata* Torrey, and *N. trigonophylla* Dunal.

Evidence of the ceremonial smoking of tobacco prior to the advent of the white man to the Americas is furnished by a bas relief carved on a stone slab that adorned the Temple of the Cross at Palenque, in the State of Chiapas, Mexico. This slab, dated A.D. 432, shows a Mayan priest enacting the ancient ceremony of blowing smoke through a tubular pipe to the four corners of the earth.

Archeologists have found, in Arizona, relics dating from A.D. 500–700 which show that the Pueblo Indians or cave dwellers of the southwestern United States were among the other tribes that long ago employed tobacco. Urns and pipes left by these Indians contain fragments of tobacco leaves and dottle. By means of chromatographic and microscopic examinations these leaf fragments and dottle were found to be those of *Nicotiana attenuata.*

As regards introduction of tobacco to Europe, *N. tabacum* was first brought to Angoulême, France, in 1556, by André Thevet. On his return from Brazil he brought seed of this species, called *petum* by the Indians, and planted them in his garden. In 1561 Jean Nicot, while ambassador to Portugal sent seed of *N. rustica* to France. Benzoni

(1565) stated that the Spaniards imported seed from Yucatan to Haiti, where tobacco crops were first grown in 1530. Extensive plantings were being made in Cuba prior to the end of the sixteenth century. These planting were made from seed obtained from Brazil, Venezuela, and the Lesser Antilles. The cured tobacco was sent to Spain and Portugal, whence a portion was distributed to England, France, and other European countries, thus marking the beginning of world trade from crops grown in the New World. In the early years of the seventeenth century, the Virginia colonists, using seed obtained from the West Indies, began the commercial cultivation of tobacco, the crops being sent to England. Thence tobacco was marketed in Continental Europe and, although it was not grown there, the habit of smoking spread rapidly among Continental Europeans, especially among the Germans, Dutch, Austrians, Bohemians, Hungarians, Norwegians, and Swedes.

Several comprehensive general accounts of tobacco, including those of Tiedemann (1854), Spinden (1950), and Brooks (1944, 1952), are replete with facts of historical interest to which the interested reader is referred. Matters of agricultural interest may be found in the works of Billings (1873), Fairholt (1876), Killebrew and Myrick (1928), Garner (1951), and Bolsunov (1959-60), and of chemical interest in those of Brückner (1936) and Shmuk (1953). But as regards treatises of comparable scope and value dealing specifically with aromatic tobacco it will be found that none exists. This is not due primarily to any lack of materials but to the fact that the sources must be sought among at least a dozen different languages. To assemble these materials and

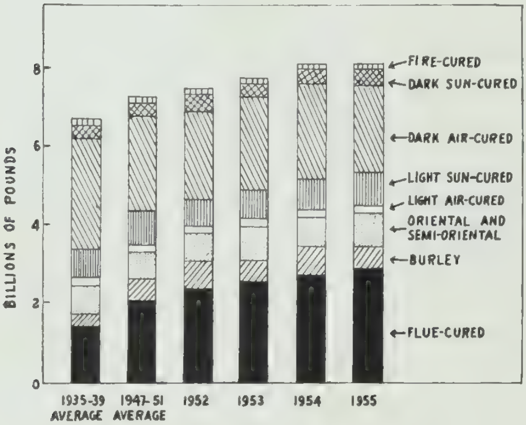

FIG. 3. Trend in world production of different types of tobacco during recent years. (Farm-sales-weight.)

to document them properly would be a Herculean task. This will not be attempted herein, but it may be pointed out that aromatic tobacco has played an immensely important role in the many, many changes that have taken place throughout the Near East.

The history of aromatic or oriental tobaccos begins about a hundred years after the discovery of America. It is known that Spanish, Portuguese, Dutch, and English traders carried seed into the countries of the Near East that border on the Mediterranean Sea. Thence the plant was introduced into contiguous inland countries. Historians have fixed the date of entry of tobacco into Turkey as 1603. Zéky (1928) believes that it was introduced in 1569, and that it was first planted in the Jenidze and Kirchaali districts (Macedonia), a region which at that time was within the Ottoman Empire. At any rate travelers in Asia Minor, Syria, and Mesopotamia (Iraq), at the beginning of the seventeenth century, called attention to the fact that the people avidly adopted the habit of smoking. The habitués crowded the coffeehouses from early morning until late at night. As an outcome, as long ago as 1611, when Sandys (1615) visited Istanbul, the Turkish government had banned smoking. In fact, it was made a crime to smoke, and offenders were punished by imprisonment or death. The sultan, Murad the Cruel, holding the opinion that smoking violated the precepts of the Koran, had approximately 25,000 people put to death in an effort to stamp out smoking. In spite of these stringent laws, however, tobacco cultivation increased rapidly in the Black Sea and Marmara Sea regions and also in Arabia. In 1683, four years after the defeat of Turkey in one of the numerous Balkan Wars, Mohammed IV came into power, and smoking was again legalized.

Among the accounts of aromatic tobaccos of general interest are those of Khodasevich, (1896), Stella (1924), D'Ammonville (1926), Philips (1926), Zéky (1928), Nesteroff (1928), Beltchev (1950), and Thassitis (1954, 1960). Khodasevich (1896) dealt with the production of tobacco in Macedonia. Matters pertaining to soils, harvesting and curing practices, and the baling and storage of tobaccos, as observed during a trip through Macedonia and Turkey, are recounted by Stella (1924). D'Ammonville (1926) and Beltchev (1950) deal primarily with agricultural, economic, and commercial problems that obtain in Bulgaria. Philips' (1926) report, written in German, is a general account of Near Eastern practices in the production of tobacco. The book by Zéky (1928), written in Arabic, contains a brief discussion of the finding of tobacco by early explorers in Brazil, of the introduction of tobacco into Europe and thence into Turkey, and of the botanical and chemical aspects of Turkish tobacco. Elaborate consideration is given also to seedbed preparation and care, crop rotation, soils, transplanting practices, cultivation, harvesting, curing, grading, baling, fermentation, manipulation in storage, marketing and export to various countries, cigarette manufacture, descriptions of the principal varieties grown in Turkey and the characteristics of the cured leaves of each, diseases and insect pests and their control, economic aspects of the industry, and lastly laws and regulations that govern the Turkish tobacco monopoly.

The two volumes by Nesteroff (1928) are popular pictorial accounts of the tobacco industry in Bulgaria, Greece, and Turkey.

The artistic volumes by Thassitis (1954, 1960) are general accounts of the most important kinds of tobacco grown in Greece. The cured leaves of important kinds are beautifully shown in color.

Present-day varieties of aromatic tobaccos are characterized as strikingly different from those of other types of tobacco. They differ from all others in size of plants, size of leaves, leaf texture, combustibility, aromatic properties, proportion of constituents, specific weight, content of resins and waxes, etc. For this reason one often encounters the question "Just what is the origin of aromatic or oriental tobacco?" Even well-informed tobacconists find it difficult to believe that all types of cultivated tobacco have one and the same origin. They find it easier to give credence to the opinion that aromatic tobaccos must have had a separate and distinct origin from that of all other types. Nesteroff (1928) stated that the origin of oriental varieties has become obscured with the passage of time to the extent that they must now be placed in a class by themselves. Certainly there is no way of knowing whether the varieties currently being grown in Turkey and Greece resemble closely those that were grown there 350 years ago. But *Nicotiana tabacum* is well known to be a plastic, adaptable, polymorphic species. Evidence of the origin of aromatic tobaccos, other than the historical evidence given earlier in this chapter, would be admissible, if it could be shown that certain present-day aromatic kinds resemble varieties belonging to other types of tobacco currently being grown in the United States. In 1948 (Wolf & Wolf, 1948) there were under cultivation at Oxford, N. C., two varieties originating from seed sent from western Greece. One was Sari de Almyros, and the other Mavra de Lamia.

The former proved to be White Burley, a well-known mutant of the Burley type, and the latter proved to be Lizard's Tail, a narrow-leafed old-line flue-cured type. The writer has examined this narrow-leafed Mavra, as grown at Drama, Greece, by Dr. D. Arghyroudis. More recently seed of a Kavala variety were planted in the Pinar del Río province of Cuba. The tobacco produced had the color, aroma, and texture of cigar leaf, but the leaf size was that of Kavala aromatic tobacco. In more recent tests seed of a Samsun, a Smyrna, and a Kavala variety were grown under shade in the Connecticut Valley. The leaves were primed and air-cured. The leaf produced possessed the color, size, texture, and aroma of cigar wrapper leaf. These same varieties, grown in North Carolina, produced leaf having the characteristics of aromatic tobaccos. Tobacconists who examined these products stated that it is incredible that one could produce two distinct types of tobacco by use of the same lot of seed. Furthermore seed of the cigar leaf variety, Guácharo, obtained from Venezuela, were planted at Oxford, N. C., and the plants were cultivated and harvested by use of the practices employed to grow aromatic tobacco. The cured leaf resembled strongly the Xanthi variety Jenidze, when grown under the same conditions.

The foregoing results may be interpreted to show that at least some varieties of tobacco have undergone little change during the time that they have been cultivated outside their place of origin. But it should be added that most aromatic varieties have been so greatly modified by hybridization and selection that they are quite unlike any varieties or types now being grown in the United States. Moreover, these results confirm the belief that the type of tobacco that may be grown from seed of a given agronomic variety depends primarily upon the interaction upon the growing plants of edaphic and climatic factors.

The fact that distinct types of tobacco can be produced from one and the same seed source, a fact that is readily demonstrable, is one of great significance that is not generally appreciated even within the industry. In the final analysis, type of tobacco and quality of the cured leaf depend primarily upon man's ability to modify the growth of the tobacco plant through control of soil conditions and weather conditions.

Problems relating to the classification of *Nicotiana* have a long history. The name *Nicotiana* was employed by Linnaeus in 1753. In *Species Plantarum* (pp. 180-181), Linnaeus dealt with four species, *N. tabacum, N. rustica, N. paniculata,* and *N. glutinosa.* Comes (1899, 1900) recognized the polymorphic nature of *N. tabacum,* and was the first to classify the many agronomic varieties, including the aromatic tobaccos, which he had assembled from all parts of the world. He separated them into six botancial varieties, namely *fruticosa, lancifolia, virginica, braziliensis, havanensis,* and *macrophylla.* Anastasia (1914) arranged the oriental varieties then being grown in Italy among the varietal groups that had been proposed by Comes. He attached special significance to the structure of the floral organs as a basis for the separation of species of *Nicotiana.*

Finally from the researches of Goodspeed (1954) extending over a period in excess of fifty years, and of those associated with him at the University of California, there has been provided a phylogenetic basis for division of *Nicotiana* into three subgenera, fourteen sections, and sixty species. It is also shown by these investigators that *N. tabacum* is a highly polymorphic natural hybrid, an amphiploid, that arose from progenitors of *N. sylvestris* and of the Tomentosae section, but whether from *N. tomentosiformis* Goodspeed or *N. otophora* is not known. The hybrid nature of *N. tabacum* thus accounts for its plasticity and for the multiplicity of differences among progeny resulting from crosses among the different agronomic kinds of tobacco. Its hybrid nature makes possible a variety of genic interactions and the production of many different combinations. Both Comes and Anastasia believed that the oriental varieties originated by hybridizations among the botanical varieties named in the classification employed by Comes. For example, Comes regarded Samsun as a product of hybridization of *fruticosa* x *havanensis* x *macrophylla;* Bafra of *fruticosa* x *braziliensis* x *havanensis* x *macrophylla;* Proseçan of *fruticosa* x *macrophylla* x *braziliensis* x *havanensis.* Rossi (1937) expressed the opinion that the Xanthi type originated from a Venezuelan variety, Barinas, once grown extensively in the State of Barinas, as a cigar tobacco. Proof for such origin is wanting, however. He said it was introduced into the Aegean Sea region about 1850.

If a history of the use of the tobacco plant for medicinal and therapeutic purposes were written, it would become an extensive account. Similarly many things of interest could be assembled in tracing the evolution of other uses of the tobacco plant. For example, the "tailored cigarette" industry is a twentieth-century development. Cigarette manufacture began as a "roll your own" proposition. Before the advent of the white man to America the Indians either smoked tobacco leaves by means of a tube or in stone pipes, or else used them as a masticatory. Upon introduction of tobacco into Europe, pipe smoking became popular and eventually this habit was largely supplanted by snuffing. In time snuffing became passé, after which cigar and cigarette smoking gained acceptance. Now as one outgrowth of two World Wars cigarettes have acquired such a degree of popularity that their consumption supports a vast industry, both domestic and foreign. Certainly no one can predict the future, but all indications point to the conclusion that man, in the foreseeable future, will not willingly relinquish the use of tobacco in any of its forms.

Summary

Tobacco originated in South America and was used in rituals and ceremonials or as medicine, and was smoked and chewed by Indians long before the coming of the white man. The Indians had introduced the seed widely in South America, Central America and North America, prior to 1492. Explorers brought tobacco seed to Europe, thence traders carried seed to the Near East at the beginning of the seventeenth century.

Of all the facts of historical importance that have been revealed as a consequence of botanical studies none is more significant than that cultivated tobacco is a natural hybrid. In consequence it is a very polymorphic species. No crop plant is more adaptable to a wide range of soils, climates, and cultural practices and none responds with greater sensitivity to climatic and edaphic factors. Undoubtedly no other crop plant is more widely diffused throughout the world. Quality of the cured leaf can be modified by even slight differences or changes in weather or in soil and cultural practices. By any standard of measurement that may be applied, no agricultural crop requires greater proficiency or expertness in its production and manipulation even though growers normally acquire this skill empirically. Moreover it remains difficult, in spite of all the evidence that has been marshaled, to believe that each of the many varieties within each of the different types of tobacco have the same ancestral origin.

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Chapter Two

AROMATIC TOBACCO PRODUCTION THROUGHOUT THE WORLD

General information

Aromatic or oriental tobaccos constitute a distinct type. The leaf is characterized as small, aromatic, flavorful, readily combustible, and of good filling properties. Some varieties of aromatic tobacco, however, possess only a small volume of aroma and are quite neutral in flavor, hence are known as semi-aromatic kinds.

The total annual production of aromatic and semi-aromatic tobaccos, during recent years, has approximated a billion pounds, thus constituting about one-eighth of all the tobaccos produced throughout the world. About two-fifths of the crop enters international trade, nearly all of it being exported from Bulgaria, Greece, and Turkey. Among other European countries that grow aromatic tobacco are Albania, Czechoslovakia, Cyprus, Italy, Rumania, Russia, and Yugoslavia; among Asiatic countries, Iraq, Iran, Lebanon, Pakistan, Russia, Syria, and the Philippine Islands; among African countries, Libya, the Federation of Rhodesia and Nyasaland, Tanganyika, and the Union of South Africa; among South American countries, Argentina and Venezuela; and in the United States a limited acreage is being grown in Georgia, Kentucky, North Carolina, South Carolina, and Virginia.

For several centuries aromatic tobacco growing was limited to the Near East, where essentially all of the crop was used domestically. But since World War I the area devoted to its production in the Aegean-Mediterranean-Black Sea regions has been greatly increased and efforts have been made to produce this type of tobacco in other countries. As a consequence, aromatic tobaccos have now become keenly competitive with flue-cured tobaccos in world trade for use in cigarette manufacture. During this course of events a phenomenal growth of the cigarette industry has taken place.

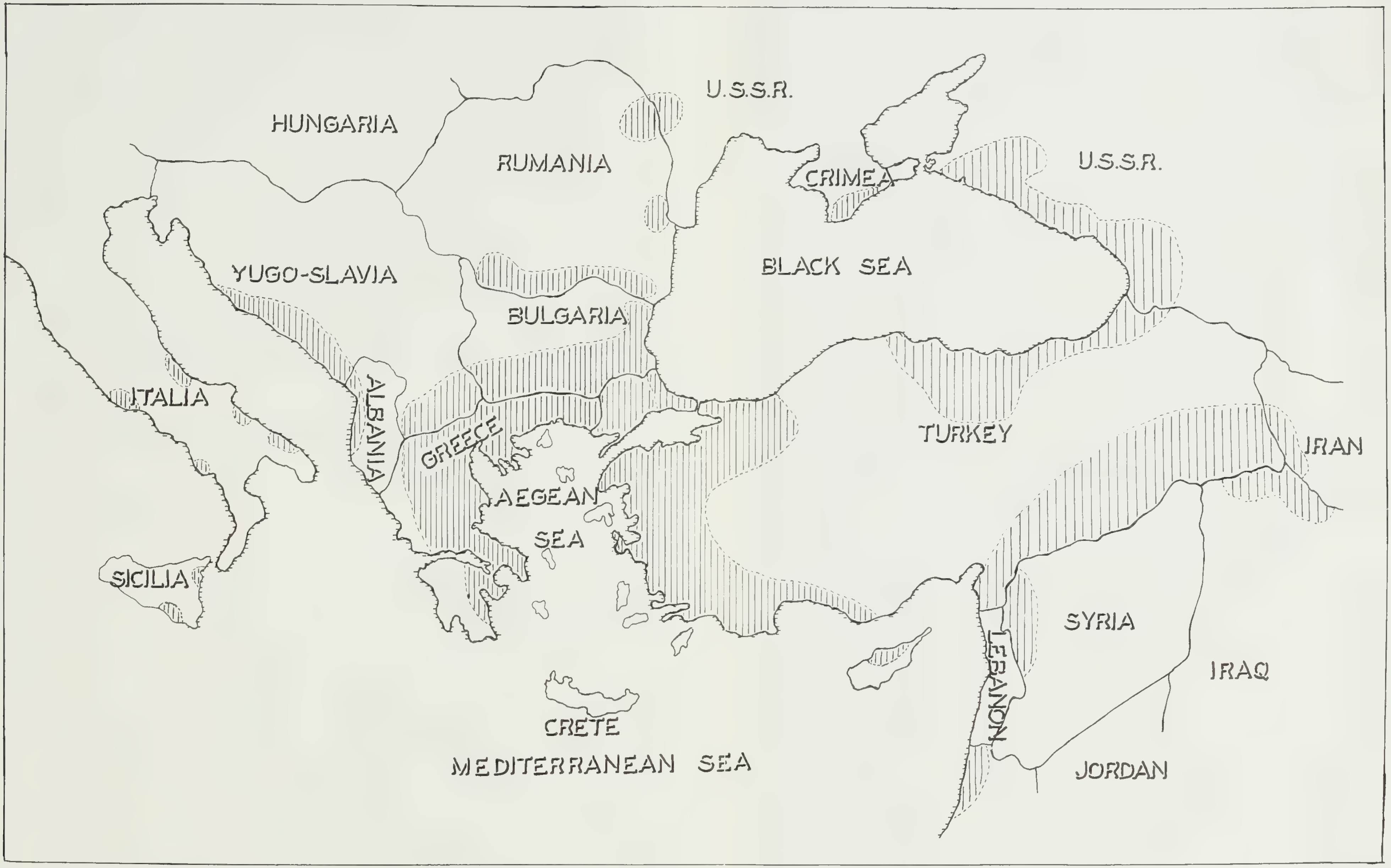

FIG. 4. Regions, in outline, in southeastern Europe and the Near East in which aromatic tobaccos are being grown.

It is well known that cigarette smoking had its beginning over a hundred years ago in the Near East, where each smoker was his own cigarette manufacturer. Moreover, the operation "roll your own" still remained a common practice throughout Europe and the Americas less than fifty years ago. It is also well known that fifty years ago only a small proportion of the population used tobacco in the form of cigarettes. But beginning with World War I there was a marked increase in demand for cigarettes, the demand coming in large measure from soldiers of the Allied armies. They not only brought with them into the European countries different kinds of cigarettes but acquired a taste for cigarettes made from blends of oriental tobaccos. As an outcome, manufacturers responded to the demand for Near East tobaccos by making brands containing a proportion of these aromatic kinds. Again, with World War II, there was a sharp increase in demand for cigarettes having oriental tobacco in the blend. The outcome has been an ever-increasing demand for all types of tobaccos used in cigarette manufacture, with increased efforts in many countries to supply these demands.

TABLE I. AVERAGE YIELD, AND PRODUCTION OF ORIENTAL AND SEMI-ORIENTAL TOBACCOS*

Countries	*Acreage harvested in thousands*				*Yield per acre, pounds*				*Production in 1000 pounds*			
	1947-1951	*1955*	*1956*	*1957*	*1947-1951*	*1955*	*1956*	*1957*	*1947-1951*	*1955*	*1956*	*1957*
Greece	213	319	291	305	531	699	623	750	113,320	222,953	180,978	226,602
Italy	69	56	56	57	762	577	798	623	52,900	32,176	44,713	35,500
Yugoslavia	80	99	94	114	656	859	710	854	52,467	81,129	62,508	100,319
Other European countries	430	504	506	519	737	773	693	744	317,060	389,400	350,600	386,000
Cyprus	1	1	1	1	500	—	200	200	295	29	200	200
Iran	28	40	47	51	615	524	523	480	17,500	20,944	24,589	24,472
Iraq	—	7	7	7	—	661	693	693	—	4,630	4,850	4,574
Lebanon	5	8	8	9	625	727	544	608	3,525	5,283	5,397	6,734
Syria	15	16	14	16	728	668	680	720	10,770	11,003	15,307	10,937
Turkey	303	379	430	426	639	676	593	606	193,749	248,189	252,139	258,642
Pakistan	—	15	16	14	—	533	750	756	7	11,039	12,000	12,100
Argentina	—	—	2	2	—	556	446	446	—	55	1,106	1,102
Morocco	—	—	—	—	—	—	—	—	—	—	6	7
Federation of Rhodesia and Nyasaland	4	—	1	2	459	—	684	650	1,836	383	700	1,300
U. of South Africa	—	—	12	12	—	—	833	667	910	839	1,000	800

*Taken from 86th Congress, Committee on Agriculture, Harold D. Cooley, Chairman.

Economic and political problems have arisen in all tobacco-producing countries as a consequence of demands for more tobacco. Suitable climate, suitable soils, and an ample supply of labor have favored Bulgaria, Greece, Turkey, and neighboring countries, as will be discussed subsequently. The lack of these essentials has impeded expansion in certain other countries. Governmental controls of production and marketing have come into being in most countries. The price differential between aromatic and flue-cured tobaccos has enhanced the competition for cigarette tobaccos in European markets, especially in Austria, Belgium, Finland, France, Germany, Great Britain, Italy, and Switzerland. In general, there has been a shift in these countries away from the straight oriental cigarette, the blended cigarette being preferred. Also more semi-aromatic and low-grade aromatic leaf is being used in place of flue-cured leaf. Such substitution is dictated largely by the cost of unmanufactured leaf.

Surplus production together with dependence upon foreign currency exchange have created additional problems, both in the countries which export aromatic tobaccos, as in Bulgaria, Greece, Turkey, and Yugoslavia, and also in certain countries receiving these exports. This entire problem, as typified by events in Bulgaria, is sharply brought into focus by Beltchev (1950), and for the Near East, in general, by the Foreign Agricultural Service report prepared by Birkhead and Davis (1958). The dependence of the economy of countries of the Near East upon foreign exchange is strikingly shown by the fact that, during the 1950-57 period, 70% of the aromatic tobacco crop grown in Bulgaria was exported, 83% of that in Greece, 72% of that in Turkey, and 46% of that in Yugoslavia. These economic matters, as they relate to countries that export tobacco, are reflected in a tabulation, Table II, taken from the report of Birkhead and Davis (1958).

It is evident from these data that there has been a sharp increase in exports since 1950. Two reasons may be assigned: (1) more cigarettes are being manufactured and smoked both in the United States and in Europe; (2) oriental leaf of median to low quality is lower priced than is the leaf of cigarette tobaccos grown in the United States, Canada, and in the southern part of Africa.

No one can foresee whether the demand for aromatic tobaccos will become increasingly larger with the inevitable increase in cost of production and increase in potential number of users of cigarettes. That mechanization of production, grading, and cigarette manufacture may

TABLE II. ORIENTAL AND SEMIORIENTAL TOBACCOS: ESTIMATED EXPORTS, BY COUNTRY OF DESTINATION, AVERAGE 1935-39 AND 1947-51, ANNUAL 1954-57 *(millions of pounds)**

Country	Average 1935-39	Average 1947-51	1954	1955	1956	1957[1]
Turkey	75.5	123.8	142.0	132.3	129.5	195.0
Greece	97.7	53.2	115.6	120.9	110.5	149.0
Bulgaria	54.2	57.8	49.2	60.2	—[2]	—[2]
Yugoslavia[3]	10.4	22.0	15.0	32.0	41.0	35.4
Italy	10.0	8.0	14.4	6.0	9.0	4.2
Iran	.5	3.6	.8	2.6	.3	—[2]
Syria	2.8	6.5	3.0	2.0	1.0	—[2]
Lebanon	—[4]	—[4]	.9	.7	—[2]	—[2]
Federation of Rhodesia and Nyasaland[5]	5.8	2.3	.2	.3	.4	—[2]
Cyprus	—[2]	.3	.4	.2	.1	—[2]
Others[6]	30.8	2.9	16.4	14.8	—[2]	—[2]
Total[7]	287.7	280.4	357.9	372.0	291.8	460.0

[1] Preliminary. [2] Not available. [3] Mostly oriental and semioriental. [4] Included in Syrian exports. [5] Exports from Southern Rhodesia in 1938-39 only. [6] Includes Hungary, Rumania, and U.S.S.R. [7] This estimate includes those not separately listed in 1956 and 1957.

* From Birkhead and Davis.

become important modificatory factors is highly probable in the light of recent developments within the industry.

The trend and status of trade of U.S.-grown tobacco with European countries is shown in Figure 5 adapted from the account by Birkhead and Davis (1958).

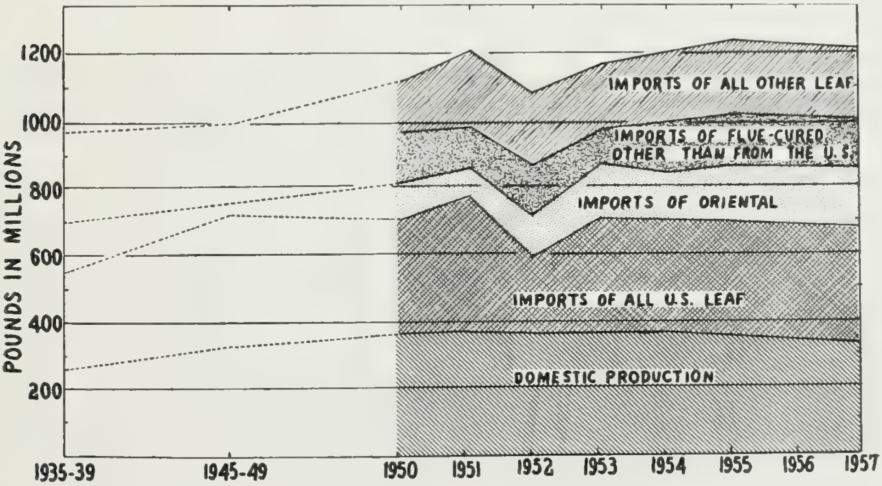

FIG. 5. Annual importation of tobacco to Western Europe from different sources.

The tobacco crop of 1958 in Turkey was estimated to be 234 million pounds as compared with 265 million pounds for the previous year. Total exports in 1956 were 134 million pounds, as compared with 195 million pounds in 1957 and 147 million pounds in 1958. There were imported by the United States 51 million pounds of the 1958 crop as compared with 88 million pounds of the 1957 crop. By West Germany 17 million pounds were imported in 1958, by East Germany, 20 million pounds, by the U.S.S.R., 11 million pounds, by Czechoslovakia, Poland, and Hungary, 22 million pounds, by France, 8 million pounds, by Italy, 6½ million pounds, and by Austria, 3 million pounds.

The tobacco crop of 1959 in Turkey was estimated to be 267 million pounds and was grown on 437 thousand acres. Of this, approximately 147 million pounds were exported. The United States purchased 72,853,000 pounds; Western Germany, 19,500,000 pounds; Eastern Germany, 6,140,000 pounds; the U.S.S.R., 3,280,000 pounds; Czechoslovakia, 8,774,000 pounds; Poland, 8,906,000 pounds; Hungary, 3,250,000 pounds; Austria, 3,476,000 pounds; Switzerland, 2,755,000 pounds; Finland, 1,803,000 pounds; Netherlands, 1,570,000 pounds; Lebanon, 1,257,000 pounds; and the United Kingdom, 4,285,000 pounds.

The discrepancies among amounts of tobacco imported by the different countries are due to the sources for the estimates and failure to indicate whether the weights were measured as metric tons or 2,000 pound tons.

TABLE III. UNITED STATES TOBACCO IMPORTS FROM PRINCIPAL SUPPLYING COUNTRIES GROWING ORIENTAL TOBACCO *(millions of pounds)*

Year	*Turkey*	*Greece*	*Syria*	*Italy*	*Cyprus*	*Yugo-slavia*	*U.S.S.R.*	*Bul-garia*	*So. Rhodesia*	*Other*	*Total*
1948	14.9	2.9	1.4	0	0	0.2	0.7	0.7	0.5	0.1	21.4
1949	45.1	9.9	3.8	0	—[1]	0.4	1.7	1.5	1.3	0.4	64 1
1950	48.2	9.5	3.8	0.3	0.1	0.3	2.4	1.3	1.3	0.4	67.6
1951	53.0	12.4	4.0	0.9	0.3	0.3	6.1	3.0	0.6	0.7[2]	81.3
1952	55.0	14.5	3.9	0.8	0.2	0.8	0	—[1]	0.6	0.1	75.9
1953	56.9	14.3	3.3	1.2	0.3	1.4	0	0	0.3	0.3	78.0
1954	56.0	15.6	2.9	1.9	0.2	2.3	0	—[1]	0.1	0.3	79.3
1955	57.7	17.9	2.4	1.5	0.3	3.3	0	0	0	0.6[2]	83.7
1956	61.5	18.9	1.6	1.8	0.5	2.9	0	0.1	0	0.6[2]	87.9
1957	61.4	23.3	1.2	1.5	0.5	3.6	0	0	0	0.6[2]	92.1

[1] Less than 50,000 pounds. [2] In 1951 includes 0.3 million pounds from Northern Rhodesia; in each year 1955, 1956, 1957 includes 0.3 million pounds from Lebanon.

Competition among cigarette types for markets in Europe and elsewhere throughout the world will no doubt intensify, rather than lessen, partly as an outcome of increase in cost of labor and elevation of living standards.

TABLE IV. TURKEY: EXPORTS OF LEAF TOBACCO, BY COUNTRY OF DESTINATION, 1950-57 *(millions of pounds)*

Country of destination	*1950*	*1951*	*1952*	*1953*	*1954*	*1955*	*1956*	*1957*	*1958*[2]	*1959*[2]
United States	40.9	69.7	51.7	72.1	64.9	38.7	47.2	88.0	43.0	73.0
United Kingdom	13.0	3.0	3.7	10.3	10.8	7.5	4.3	2.8	—	—
Belgium	4.5	3.8	5.5	5.5	3.0	2.0	1.6	1.1	—	1.2
Denmark	2.0	0.4	0.3	0.3	0.4	0.3	0.4	0.3	—	—
France	3.2	6.7	2.3	4.4	5.0	4.7	5.1	6.1	—	4.4
Finland	1.4	2.4	2.5	3.3	2.4	1.7	3.1	1.3	—	1.8
Italy	1.8	1.7	3.2	6.8	1.5	7.4	5.1	6.5	—	—
Netherlands	1.9	0.3	1.2	1.3	0.5	0.6	0.2	0.4	—	1.6
Norway	1.0	0.2	1.1	0.9	0.2	0.9	0.6	0.4	—	—
Spain	—	—	1.1	1.9	—	1.5	—	0.3	—	—
Sweden	2.0	1.1	1.8	1.6	1.8	0.6	1.1	0.7	—	—
Switzerland	2.5	1.6	2.8	3.0	2.9	2.5	3.2	1.9	—	2.1
West Germany	13.4	9.7	20.8	21.0	12.0	11.9	14.1	17.2	14.0	20.0
Austria	6.7	3.6	4.1	3.5	2.1	3.0	3.4	3.4	—	3.5
East Germany	—	—	3.1	2.3	12.2	10.1	14.0	21.8	14.0	6.0
Yugoslavia	—	2.5	—	—	—	3.2	—	3.3	—	—
Czechoslovakia	4.7	2.9	0.6	3.5	4.1	5.5	9.2	11.7	—	9.0
Hungary	—	0.5	5.7	2.2	2.4	3.4	2.1	2.2	—	—
Poland	1.4	—[1]	0.2	—	4.8	13.2	8.6	11.5	—	9.0
U.S.S.R.	—	3.7	5.8	—	1.1	—	0.6	2.3	—	3.25
Other	11.6	13.2	7.5	14.1	9.9	13.3	10.1	7.8	—	—
Total	112.0	127.0	125.0	158.0	142.0	132.0	134.0	191.0		

[1] Only 44,000 pounds. [2] From *Tobacco*.

Groups of oriental tobaccos

The oriental tobaccos comprise several groups within each of which the leaf is quite distinct, even though the source of seed may be the same. These differences in color, texture, leaf size, kind and volume of aroma, flavor, combustibility, specific weight, nicotine content, content of nitrogenous substances, carbohydrate substances and other compounds, and content of ash. These differences are causally related to edaphic and climatic factors, such as to soil moisture, slope, available nutrients, elevation, prevailing winds, prevailing temperatures and relative humidity, etc. Several clearly defined varieties make up each group, and many of the varieties derive their names from the town or village near which they are grown.

No accord exists on the bases for the larger groupings of aromatic tobacco. Nesteroff (1927) includes all of the Mediterranean-Black Sea kinds in nine groups as follows: (1) Xanthi tobaccos; (2) Macedonian tobaccos; (3) Bulgarian tobaccos; (4) Thessalian or Western Greek tobaccos; (5) Smyrna tobaccos; (6) Aegean Islands tobaccos; (7) Samsun tobaccos; (8) Anatolian tobaccos; and (9) Russian tobaccos. This scheme leaves out of account those grown in other parts of the Near East and in other countries. Birkhead and Davis (1958) make producing country the primary basis for groupings, a plan followed by the present writer.

Tobacco production in Turkey

Regulation became necessary as a result of increased demand for Turkish tobacco immediately after World War II. The quality of the leaf produced declined because unsuitable lands were planted by inexperienced growers. As a result, regulation of production of tobacco in Turkey by the Turkish Monopoly (Tekel) was strengthened. Officials from the Monopoly advise the grower on the suitability of his fields and inspect the growing crop to estimate quality and quantity. The Monopoly buys leaf from the grower, owns and operates the fac-

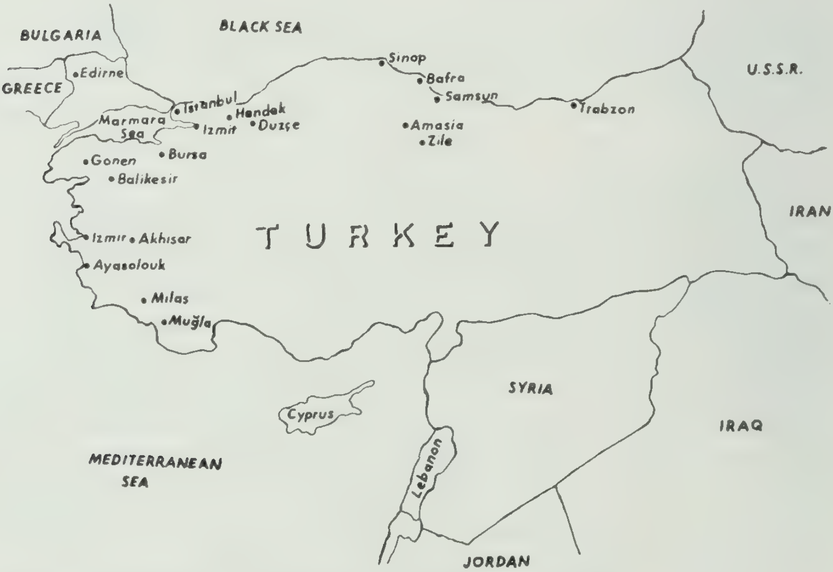

FIG. 6. Some of the most important tobacco marketing centers of Turkey.

tories, distributes the manufactured product, and negotiates export sales. The growers deliver the crop to designated centers, where it is graded, stored, and fermented. The Monopoly is responsible for issuance of permits to merchants or to the government itself to export tobacco. Bilateral trade agreements or barter agreements govern shipments by the Turkish Government not only to the United States and western Europe but also to the Soviet Bloc nations, and account for more than half of the exports. The trend in the export sales is shown in Table V.

TABLE V. PRODUCTION AND EXPORTATION OF TOBACCO, TURKEY*

Year	*Area, hectares*	*Production, tons*	*Export, tons*
1945	98,049	69,599	38,072
1946	123,248	97,952	38,536
1947	132,480	101,928	42,293
1948	106,099	83,079	49,168
1949	127,419	100,085	77,625
1950	128,339	93,328	49,237
1951	121,361	88,651	56,191
1952	130,047	91,958	55,889
1953	159,026	117,795	70,705
1954	156,072	102,242	62,908
1955	172,725	120,143	58,359
1956	175,666	116,570	69,307
1957	169,980	123,388	76,624
1958	161,626	103,773	51,921

* Data supplied by Dr. F. Ipekoğlu, Cevizli-Maltepe, Turkey.

Currently, approximately 25% of the total tobacco crop in Turkey is grown in the Black Sea region, 19.5% in the area bordering the Marmara Sea, 50.5% in the Aegean region, and 5% in the Southeastern area. As regards varieties, those of the Black Sea region are Artvin, Bafra, Gumucke, Hadjeköy, Samsun, Tachova, Dere, Maden, Gerze, Orençik, and Trabzon; of the Marmara Sea region, Balikessir, Brusa, Duzçe, Gönen, Hendek, Izmit, and Thrace; of the Aegean region, Akhisar, Ödemiş, Ghiavourköy, Lighda, Milas, and Muğla; of the Southeastern area, Bitlis, Diyarbarkir, Malatya, Iskenderun, and Gaziantep.

As shown, the United States and Germany receive the largest quantity of the aromatic tobaccos grown in Turkey. But it is of interest to note the increased shipments to Bulgaria, Czechoslovakia, Poland, the Eastern Zone of Germany, and Yugoslavia, some of which is procured to be re-exported.

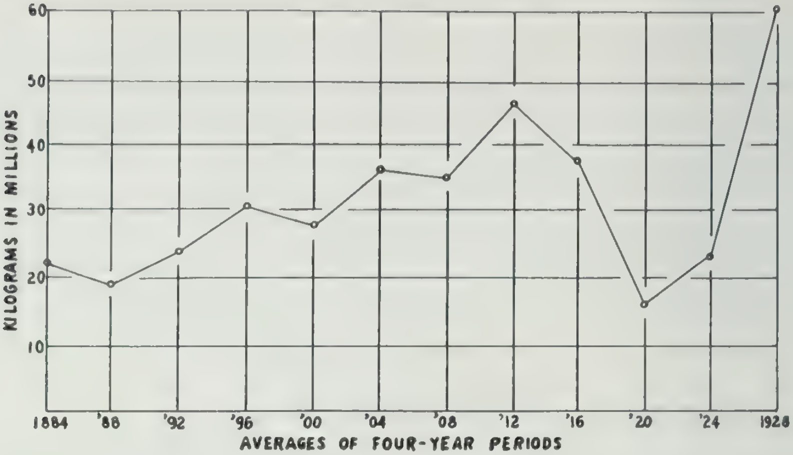

FIG. 7. Production of tobacco in Turkey during the period 1884-1928 from data by Zéky (1928). Approximately 790 kilos per hectare.

Attention should be called to the fact that many centers, readily accessible to farmers, are provided for grading, storage, manipulation, and shipment of the Turkish tobaccos. Of these, Istanbul occupies the most important position in the Near East. Here are many warehouses and factories, and also the banks and business offices of those connected with domestic and foreign merchandising and the export facilities. Istanbul is the headquarters for all the tobacco that is intended for export that is brought from the cities of Trabzon, Bafra, and Sinop in the Black Sea region, and also from Izmit, Brusa, Gönen, and other cities in the Anatolian region bordering the Marmara Sea, from Edirne (Adrianople) in Turkish Thrace and from Izmir in western Turkey. Moreover crops grown in the U.S.S.R. along the eastern coast of the Black Sea, and in Crimea (Krim) are shipped to Istanbul to be sold in world markets.

In western Turkey, Izmir is the business center and center for manipulation for a large area, drawing its supply of tobacco from Akhisar, Bergama, Ghiavourköy, Lighda, Muğla, Milas, Sevindiköy, Ödemiş, and Thyra and the many small towns and villages that surround these centers.

Buyers of Turkish tobaccos for export come to Istanbul and Izmir to make their purchases. Here they expect to find stocks of certain of the better known varieties originating in one or the other of the three principal regions of Turkey. From the Aegean region come Ayasolouk, Botch, Feshie, Ghiavourköy, Milas, Muğla, Scalanova, Tchesme and Torbali; from the Black Sea region, Alaçam, Bafra, Basma; from the Province of Amasya, Dere, Djanik (Çanik) Evkav, Gerze, Maden, Samsun, Tachova Çarşamba (Tcharshamba), Trabzon, and also such varieties from the U.S.S.R. as Sochi-Adler, Maikop, Sukhum, Kuban, and Yalta; from the Marmara Sea and Thrace region, Brusa, Duzçe, Gönen, Hendek, Izmit, and Thrace. Little information is available on the origin and genetic make-up of the Turkish varieties or other aromatic varieties of tobacco. But each of them is characteristically different in part because of the influence of climatic conditions and soil. Buyers desiring a product that is fine in texture and also highly aromatic purchase, as a first choice, Ghiavourköy, from the Aegean region, with Sevindiköy, Botch, Ayasolouk, and Scalanova next in descending order.

In the Black Sea region Samsun and Bafra are most desirable, followed in order by Maden, Dere, Çanik, Evkav (Efkaf), and Çarşamba. In the Marmara Sea region, Duzçe (Duzdce) holds first place.

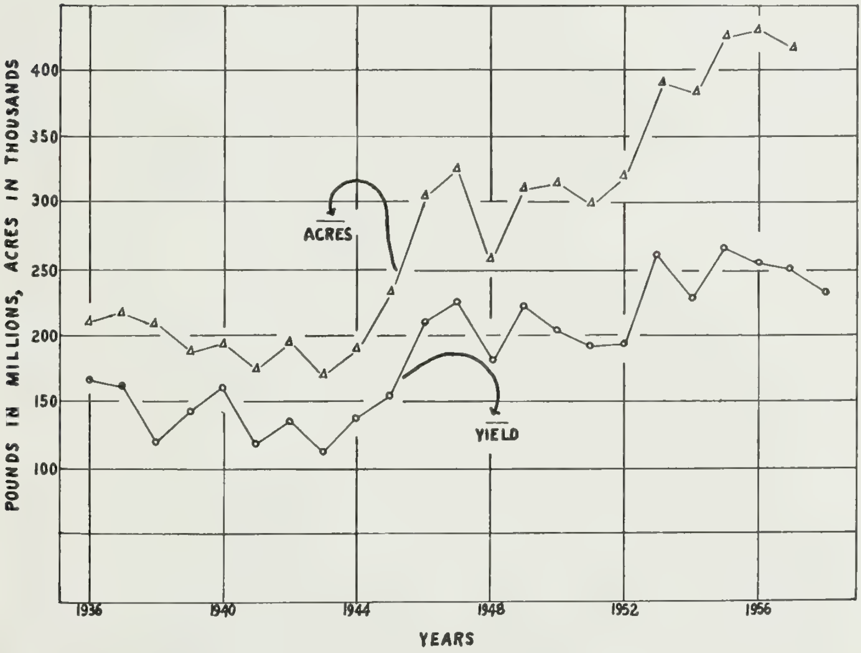

FIG. 8. Acreage and pounds of tobacco grown in Turkey from 1936 to the present. Data from the Turkish Central Statistical Office, supplied by Sabahattim Dumer.

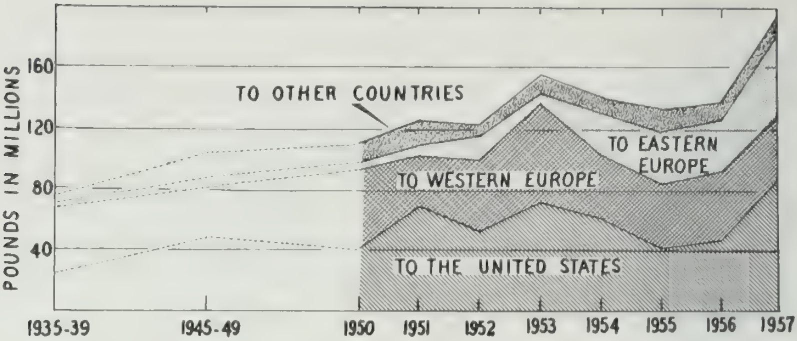

FIG. 9. Tobacco sales of tobacco grown in Turkey. From Birkhead and Davis, 1958.

Many of the varieties whose names are given in the foregoing lists and others not so well known or so distinctive are mild to neutral in aroma and flavor, but find a ready market, being used as filler for cigarettes.

Tobacco production in Greece

The tobacco industry of Greece is under the control of the Hellenic Tobacco Board, with offices located in Athens and branch offices in Kavala, Thessaloniki, Volos, and Agrinion. The Tobacco Research Institute of Greece at Drama was established in 1930, as an agency of the Hellenic Tobacco Board. This research institute deals with various agricultural, phytopathological, and chemical problems, such as seedbed preparation and care, improvement of varieties by selection and hybridization, production of seed for free distribution to growers, the effects of fertilizers and cover crops on yield and quality, the improvement of cultural practices, the prevention and control of diseases, the control of insect pests in the fields and storages, the relation of chemical composition to quality, and the improvement of practices to reduce costs and increase quality during manipulation in the villages and in storage depots.

Bilateral trade agreements presently provide for Greece an estimated 40% of the total foreign exchange earnings, most of which come from tobacco. However, as an outcome of economic conditions arising directly from World War II and extending for several years thereafter both production and export became chaotic. In 1950 the total production amounted to 128 million pounds, only 56 million pounds of which was exported. By 1957 production had increased to 240 mil-

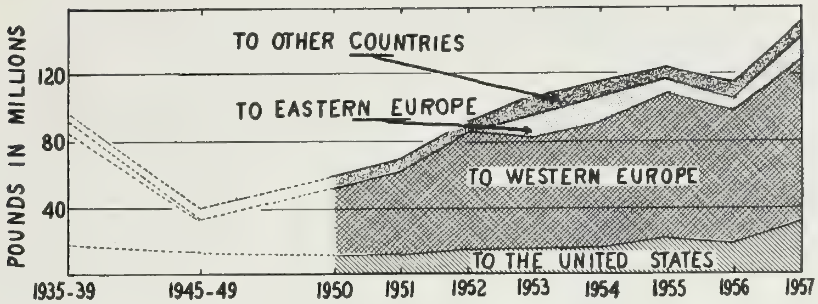

FIG. 10. Annual exportation of tobacco from Greece. From Birkhead and Davis, 1958.

lion pounds, 149 million pounds being exported. The United States and western Europe largely provided the export market as shown graphically in Fig. 10.

As is apparent from the data in Table VI, western Europe is the most important purchaser of Greek tobaccos, the United States holding second place.

Although Greece has no tobacco monopoly comparable in scope of control to that in Turkey and Italy, yet the government exercises control over loans to farmers to aid in production and extends credit to merchants for use in buying, manipulating, and storing tobacco. It also concerns itself with problems of improvement of the grading practices, of proper baling, of price stabilization, and of promotion of exports, all directed toward establishing a balanced relation between supply and demand. However there are no acreage restrictions.

Athens is the center of all activities connected with Greek tobacco. Here are banks, warehouses for manipulation and storage, and offices for domestic and foreign buyers. The shipping facilities not only for tobacco but for all other agricultural products are located at the port city, Piraeus. From this port all kinds of Greek tobacco, Macedonian, Thracian, Western Greece, and Aegean Islands, even tobaccos from districts in Bulgaria and Yugoslavia, are shipped to the markets of the United States and of Europe. Kavala is next in importance to Athens, with many warehouses for manipulating and storing, and port facilities. The varieties Kavala and Pravista grown nearby are excellent in quality but generally are regarded as inferior to the Xanthi types produced in the Xanthi, Serres (Serrai), Drama, and Zihna (Zichna) districts.

Salonika (Thessaloniki), the capital of Macedonia, also has numerous tobacco warehouses and shipping facilities for handling the same varieties as are marketed at Kavala.

TABLE VI. GREECE: EXPORTS OF LEAF TOBACCO, BY COUNTRY OF DESTINATION, 1950-57 *(millions of pounds)**

Country of destination	*1950*	*1951*	*1952*	*1953*	*1954*	*1955*	*1956*	*1957*	*1958*	*1959/60*
United States	11.4	10.9	13.8	13.3	14.3	22.7	20.8	29.5	13.3	28.21
West Germany	14.1	17.3	40.9	34.8	37.9	41.7	34.9	50.9	34.7	33.03
United Kingdom	1.1	1.6	2.1	3.8	2.5	2.8	1.2	2.0	3.8	2.83
Austria	4.8	5.6	5.0	6.8	6.8	5.8	9.6	8.0	6.8	3.69
Belgium	—	0.1	0.4	0.6	0.9	3.4	4.7	5.7	0.5	3.77
Denmark	0.9	0.3	—[1]	0.2	—[1]	—	—	—	0.2	0.65
France	6.7	15.8	13.0	9.8	10.6	13.3	9.3	12.3	9.8	10.62
Finland	4.5	2.2	3.0	2.0	4.2	2.9	4.1	2.5	1.9	2.41
Italy	3.2	5.6	1.5	3.5	9.5	7.9	6.1	10.2	3.5	4.70
Netherlands	0.3	0.4	0.2	0.7	0.3	1.3	0.6	0.9	0.7	1.29
Norway	0.2	—[1]	0.3	0.1	—[1]	—	—	—	0.1	0.28
Spain	—	—	—	2.4	0.4	—	—	—	2.4	0.32
Sweden	1.6	1.2	2.9	2.0	1.0	1.0	1.6	2.4	2.0	2.27
Switzerland	1.9	1.1	2.2	2.2	2.9	3.5	2.7	2.0	2.2	2.98
East Germany	—	—	—	4.1	6.5	2.6	1.7	1.8	4.1	0.10
Yugoslavia	—	—	—	5.0	0.2	—	—	—	5.0	—
Czechoslovakia	—	—	—	—	—	—	0.3	1.0	4.3	5.96
Hungary	—	—	—	4.2	2.4	3.9	0.6	3.4	0.5	2.33
Poland	—	—	—	—	—	—	0.5	0.5	4.9	3.77
U.S.S.R.	—	—	—	—	8.2	1.4	4.3	6.7	6.8	12.04
Others[2]	5.5	7.3	6.1	12.4	7.0	7.1	7.4	9.1	—	4.63
Total	56.2	69.4	91.4	107.9	115.6	121.3	110.4	148.9	107.5	125.88

[1] Less than 100,000 pounds. [2] Not otherwise accounted for, probably small shipments.
* From Birkhead and Davis (1958).

Those tobaccos known as "Island Tobaccos," grown on the islands within the Aegean Sea, are marketed largely from towns on these islands. Among these market towns are Wathy on Samos, Mytiline on Lesvos, and Candia (Irakalion) and Canea (Khania) on Crete.

Attention should be directed to Drama, a city of increasing importance to the welfare of the tobacco industry of Greece, because it is the home of the agricultural experiment station at which important studies of Greek tobaccos are being conducted further to improve culture practices, varieties, and quality of the leaf.

Varieties of Greek tobacco

The tobaccos of Greece, for convenience, may be divided into four groups: Xanthi, Macedonian, Thessalian or Western Greece, and Aegean Islands. Within each group are several districts, each producing quite a different product. But among all aromatic tobaccos none is superior to the Xanthi or Basma tobaccos. This group includes such Basma superior quality kinds as Xanthi Yaka I, Xanthi Yaka II,

TABLE VII. PRODUCTION AND EXPORTATION OF TOBACCO, GREECE*

Period	Hectares planted	Production (metric tons)	Export (metric tons)
1945	45,528	19,104	171
1946	68,613	28,097	12,917
1947	78,529	47,141	17,920
1948	72,786	36,598	18,485
1949	81,204	52,776	28,181
1950	103,352	58,451	26,330
1951	96,327	62,557	31,029
1952	76,525	39,546	41,430
1953	87,956	60,972	48,924
1954	106,160	67,398	52,699
1955	128,402	101,002	55,009
1956	117,578	82,136	50,099
1957	121,983	109,853	67,559
1958	112,371	84,275	61,907
1959[1]	102,000	75,842	58,389
1960[1]	92,000	68,100	—

[1] From *Tobacco.*

* Data supplied by Dr. T. Andreadis, Director, Hellenic Tobacco Board, Athens, Greece.

Xanthi Djebel, Chrysoupolis Djebel, Xanthi Souyalissi, Xanthi Dere, Mahala, Gümüldjina (Komotini), Kiuchouk Yaka, Zichna I, Zichna II, Jenidze (Yenidze), and Kir. Among the medium Basma kinds are Komontini, Pravista, Drama, Serres, Nigrita, Sidirokastron, Kavala, Orta Kolöy, and Yaka II. As regards inferior Basma kinds, they include the Ovas or varieties grown on the plains or lowlands together with the less desirable Yakas and Djebels. The Greek Macedonian group includes Katerini (from seed from Samsun), Proseçan (Prosotchani), Trebizond (Trabzon), Salonika, Kabakulak, and Etoloakarania, all of the Bachi-Bagli type with larger leaf than the Xanthi and with distinctive aromas. Certain of the tobaccos in the Zichna, Mahala, Serres, Kir, Pravista, and Nigrita districts, bearing these varietal names, also belong in the Macedonian group.

The aromatic varieties in the Western Greece or Old Greece group include Agrinion, Zichna de Kanalion, Volos, Almyros, Argos, Myrodata, and Dzembelia. Some of Thessalian varieties on being cured tend to be dark; others yellow. The dark tobaccos are termed *mavra* (black) but the word *skotinos* (dark colored) appears preferable, and the yellow ones *saria* (*sari* in Turkish) with kitrinos or xanthos being preferable. Lastly there is the Aegean Islands group with varietal names corresponding to the names of the several islands, as Samos, Nexos, Lemnos, Skyros, Chios, etc. The crops grown near the town Almyros, Karditza, Trikala, Larissa, and nearby villages are handled in warehouses at Volos whence they are exported. Such tobaccos are known in the trade as "Volo tobaccos." The crops grown in the region surrounding Agrinion, Tsembelia, Kalavryta, and Myrodata, known as "Agrinion tobaccos," after being manipulated at Agrinion, are taken to Patras (Patrai) on the west coast for shipment. The city of Argos, located in the heart of an important producing region of Old Greece, is the marketing and manipulating center for the area. These tobaccos are then transported to the port city, Nafplion, to be sent to Piraeus, the port for Athens, or else are exported directly to world markets.

Since the establishment of the Institute for Tobacco Research at Drama, Greece, efforts have been made to reduce the number of varieties grown in favor of varieties having best quality and highest yield, as demonstrated by field trials. Arghyroudis (1949) stated that currently 45% of the area of the hill and mountain regions of Macedonia and Thrace is devoted to Basma.

Races of Basma, differing from each other in aroma, originating as natural crosses have been obtained by selection, but none is too well stabilized. Those employed are designated Basma de Xanthi, Basma

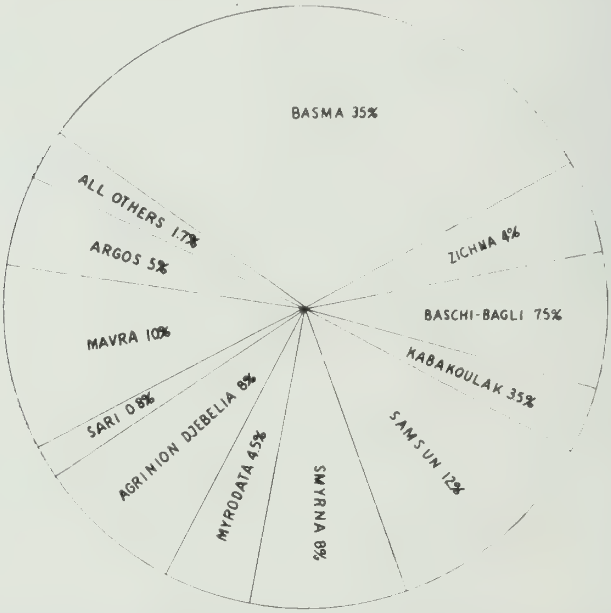

FIG. 11. Varieties of tobacco grown in Greece and the proportion of the total crop of each variety. After Thassitis, 1954.

de Serres, Basma de Nigrita, Basma de Machala (Mahala), etc. Thassitis (1954) grouped the many varieties being grown and gave an approximation of the percentage contribution of each group to the total production, Fig. 11.

In the immediate region of Drama 12% of the areas is planted to Bachi-Bagli, one of the best varieties of which is Myrodatos (Myrodata) de Agrinion. In eastern Macedonia 12% is planted to Smyrna, and 2% to Kabakulak. In the region surrounding the cities Agrinion and Lamia, Tsembel (Tsembelia) de Agrinion occupies 10% of the area. About 5% of the area near Katerini and Salonika (Thessaloniki) is planted to Samsun. In central Greece (Thessalia) 4% is Sari, an equal area is Mavra and 2% is Zichna-Canalia. In the area surrounding Argos 3% is Argos.

Tobacco production in Rumania

The tobacco industry in Rumania is a governmental monopoly. Production has steadily increased during the past ten years to an annual amount of approximately 100 million pounds. This has come about in spite of the annexation by the U.S.S.R. of Bessarabia and Bukovinia, provinces in which a great deal of the Rumanian crop was formerly produced. The amounts that reach export markets are inappreciable. Instead, tobaccos are imported from Greece and Turkey to satisfy domestic demands for cigarette manufacture.

Yaka kinds are grown in the southern and southwestern parts of the country, using seed sources from the Macedonian districts of Greece, and the Izmir and Samsun districts of Turkey. From these varieties Rumanian growers are able to produce leaf of good color and of good filling power in the manufacture of cigarettes. Yaka, Ayasolouk, Prosotchan, and Samsun are among their best varieties.

Several varieties of semioriental tobaccos, having the names Ghimpatzi, Molovata, and Dragasani, are grown, especially in the northeastern part of Rumania. Near the Hungarian and Yugoslavian border, and in the plains of the Danube River and Tiza River, the two varieties, Ialomitza (Yalomitza) and Sătmărean find favor. They are dark kinds yet may be regarded as semioriental varieties and are good filler tobaccos.

Tobacco production in the U.S.S.R.

Not a great deal of information is available about the production of aromatic tobacco in the Soviet Union. There are several districts in which large quantities of oriental kinds are grown. These include the Crimean region and those in the territory along the eastern coast of the Black Sea. The Xanthi types of Basma are grown along the southern coast of the Crimean peninsula, the varieties there being known as Yalta and Yalta-Dubek (Dzhubek). The districts of the eastern Black Sea region are designated Kuban, Maikop, Sukhumi (Sochum), and Sochum-Adler, Mingrellien, and Djaristan.

The tobaccos of the Kuban and Maikop districts are Trabzon varieties with large leaf and tend to be neutral fillers tobaccos. In some parts of these districts the same varieties are flue-cured. The varieties of the Sukhumi and Sochum-Adler districts are derived from Samsun and Bafra kinds. Some U.S.S.R. crops received in the United States prior to World War II were found to be pleasingly aromatic and of good color, texture, and combustibility.

Krasnodar is among the world's best known centers for researches on tobacco. Sebastopol in Crimea and Batumi, Sochum, Adler, Sotchi, Tuapse, and Novorosiisk along the Black Sea coast are large centers for manipulating and storing the aromatic tobacco crop.

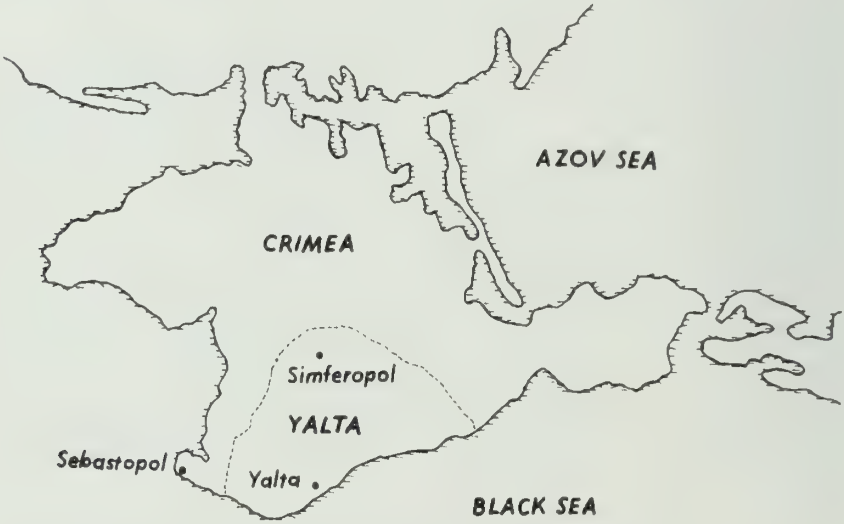

FIG. 12. Yalta tobacco area of Crimea and marketing centers.

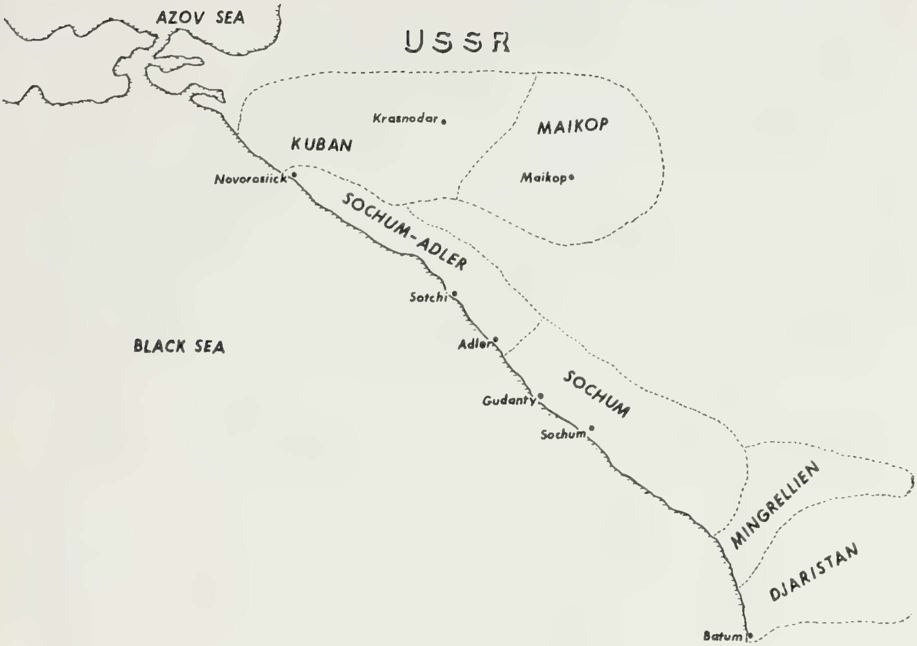

FIG. 13. Tobacco growing regions of the U.S.S.R. along the eastern border of the Black Sea and centers of manipulation and exportation.

Large amounts of oriental leaf from Bulgaria, Yugoslavia, Greece, Iran, and Italy are imported into the Soviet Union, and thence re-exported to Finland, Eastern Germany, Czechoslovakia and to the countries of western Europe.

Tobacco production in Bulgaria

There are four aromatic tobacco growing districts in Bulgaria—the Macedonian, Southern Bulgarian, Rhodopo-Thracian and Northern Bulgarian. Sometimes the Southern Bulgarian and Rhodopo-Thracian districts are regarded as parts of one district. As shown by Beltchev (1950), for a long time tobacco has been very important in the economy of this country. Although the tobacco industry is under governmental control and special efforts have been made to bolster the Bulgarian economy by increasing production, nevertheless, the government has met great difficulty in finding export markets to absorb the output. Exports have gone mainly to the U.S.S.R., Poland, Czechoslovakia, and East Germany, some of it no doubt having been re-exported by the eastern European Communist Bloc countries. Belgium, Italy, France, and Austria also are supplied with Bulgarian aromatic tobaccos. An average of about 70% of the crop produced since 1950 has been exported. The production by years, beginning in 1951, has been as follows: 1951, 128 million pounds; 1952, 90 million pounds; 1953, 115 million pounds; 1954, 106 million pounds; 1955, 145 million pounds; 1956, 106 million pounds; 1957, 160 million pounds, a total of 850 million pounds during this period of seven years. Per-acre production ranged from 409 to 727 pounds, an average of 565 pounds. The best quality or Basma leaf of Bulgarian tobacco is grown in the provinces along the border of Greece. These areas have the same kinds of soil and climate, and the cultural and grading practices are quite like those used in Macedonian and Thracian Greece.

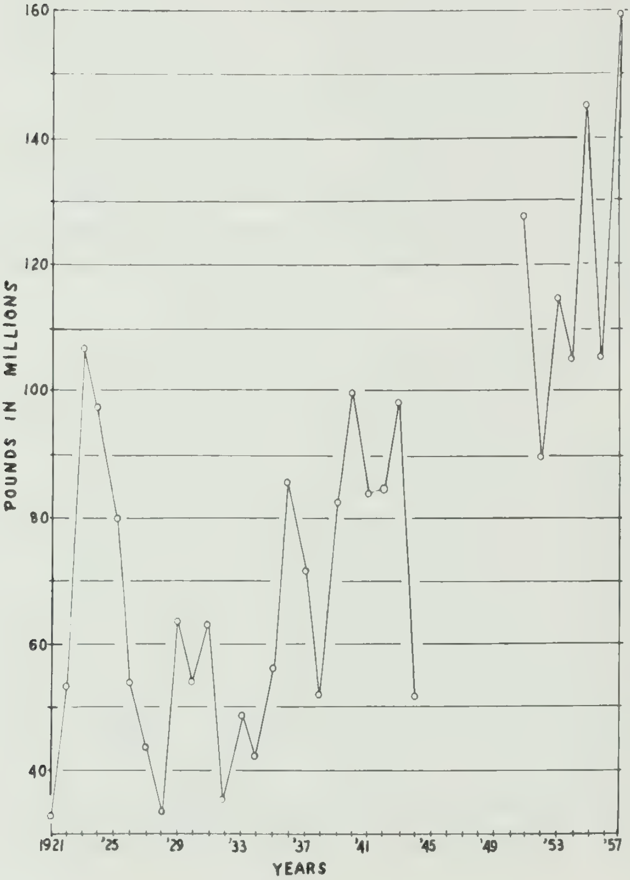

FIG. 14. Annual production of aromatic tobaccos in Bulgaria.

As in Greece, the Bashi-Baly (Bachi-Bagli) and Basma kinds are graded commercially into Djebel (mountain), Yaka (foothill crests), and Ova (plains) groups. The varieties grown include Philipopple (Plovdiv), Stanimaka (Asenovgrad) Djebel, Haskovo (Khaskovo), Balkan, Haskovo-Ova, Kochoukavak, Pazardik, Ortaköy, Nevrokop, Peruschtitza, Doupnitza, Melnik, Petritsch, and Djumaja (Dzhumaja). The Bashi-Baly kinds are produced largely in the Macedonian District; Melnik, Nevrokop, Doupnitza, Djumaja, and Sofia being the marketing and manipulating centers. In Sofia, the capital of Bulgaria, are the offices of governmental, financial, and commercial agencies that control the country's tobacco industry. However Philipopple, known to Bulgarians as Plovdiv, is the most important marketing and manipulating center for the crop in the Macedonian District. More than half of all Bulgarian tobacco is processed in Plovdiv.

Haskovo (Khaskovo), in the Southern Bulgarian District, is second to Plovdiv in importance as a processing and marketing center. In this city much of the Haskovo-Balkan tobaccos is handled, but it receives, additionally, large amounts of the crops grown in the vicinities of Ortaköy, Kirdhjali (Kürdzhali), Mastanli, and Kochoukavak.

Apparently little of the crop produced in the Northern Bulgarian District, except that near Varna, finds favor in export markets. Varna and Burgas on the Black Sea are the outlets for export from northern Bulgaria.

One feature that militates against the Bulgarian crop is the use of artificial fermentation rather than natural fermentation. This is done to secure a more rapid return on the capital invested. As a result of high temperature and high relative humidity, there is deterioration of both aroma and color by artificial fermentation.

Tobacco production in Yugoslavia

In recent years the production of tobacco in Yugoslavia has increased rapidly, the 1957 crop being 127 million pounds, approximately 80 million of which was aromatic or semiaromatic. The best region is an extension of the Macedonian area of Bulgaria and Greece. Prilep, having a Basma type leaf, which produced in 1957 a yield of 30-35 million pounds, is the best variety. Other choice varieties are Yaka Kyretchilere and Otlia. The marketing and manipulating centers are Skopje, Stroumitza, Tikvech, and Prilep. A large amount of Prilep

TABLE VIII. EXPORT OF AROMATIC TOBACCOS FROM YUGOSLAVIA 1955-59
(thousands of pounds)

Buyers	*1955*	*1956*	*1957*	*1958*	*1959*
U.S.A.	5,530	1,918	3,438	8,160	2,992
U.S.S.R.	1,776	7,009	2,204	—	—
Italy	2,205	2,645	1,587	1,984	1,870
West Germany	1,406	2,502	529	1,314	926
Poland	1,212	2,204	1,102	1,984	2,479
China	—	2,352	1,788	4,098	—
France	2,546	1,726	1,179	3,923	3,498
Czechoslovakia	1,510	507	—	948	1,492
Sweden	—	287	440	220	838
Hungary	—	617	—	176	—
Egypt	22	99	1,523	820	983
East Germany	298	—	—	2,860	1,881
Others[1]	—	—	—	730	1,522

[1] Austria, Belgium, England, Finland, The Netherlands, Morocco, Switzerland, and Tunisia are among the other countries that purchase tobacco from Yugoslavia.

from the crops of 1956 and 1957 was exported to the United States.

The varieties having large leaf that is only mildly aromatic, hence semioriental, are Trebinjak, Ravnjak, and Herzegovina. Their production, in 1957, was 45-50 million pounds. Trebinjak is said to have been derived from Trabzon. All are grown in the Macedonia area. Herzegovina is grown also in an area along the Adriatic Sea, in the provinces of Bosnia and Herzegovina.

In 1945 an institute for tobacco research was established in Prilep to deal with problems of varieties, agronomic practices, soils, chem-

TABLE IX. YUGOSLAVIA: PRODUCTION AND EXPORTS OF ALL KINDS OF TOBACCO, AVERAGE 1935-39 AND 1945-49, ANNUAL 1950-57
*(millions of pounds)**

	Year	*Production*[1]	*Exports*[2]
Average	1935-39	37.4	10.4
	1945-49	62.2	18.4
Annual	1950	34.9	17.3
	1951	61.3	13.8
	1952	32.7	18.5
	1953	65.2	13.5
	1954	64.4	15.4
	1955	91.4	32.3
	1956	67.7	44.2
	1957	122.8	35.4

[1] Farm sales weight. [2] Fermented weight.
* From Birkhead and Davis (1958).

istry, diseases, and insect pests. Field stations are located at Bitola, Delchevo, Kovadar, Resen, Skopje, Srouga, Stroumitza, and Tetova.

Tobacco production in Italy

Aromatic and semiaromatic tobaccos are grown in the provinces of Abruzzi, Basilicata, Campania, Lazio, Molise, and also in parts of the islands of Sardinia and Sicily. However the quality of Italian grown Xanthi-Yaka differs sufficiently from that grown in Greece that it cannot be sold in competition in world trade. The leaf is larger and less aromatic but is equally bright colored and light-bodied. Moreover, efforts to grow Samsun, Proseçan, and other highly prized varieties have met with rather poor success, the product lacking aroma and filling power. A considerable quantity of such varieties as Herzegovina and Peruschtitza is grown and for the most part is used domestically.

The total annual production of aromatic tobaccos averages about 20 million pounds. In turn, Italy imports leaf from Bulgaria, Greece, and Turkey, a portion of which is re-exported. These shipments have ranged from about 2 million pounds to 14 million pounds in recent years, but accurate information on the amounts, varieties, and sources of production is not available. The United States and Switzerland, however, purchased a large proportion of these exported tobaccos.

TABLE X. PRODUCTION OF AROMATIC TOBACCO IN ITALY *(kilograms)**

Year	*Variety*			*Total*
	Xanthi Yaka	*Perustitza*	*Erzegovina*	
1954	8,739,674	4,199,860	6,504,095	19,443,629
1955	9,713,762	3,477,859	7,079,466	20,271,087
1956	10,711,645	3,306,789	6,079,925	20,098,359
1957	10,205,196	3,744,883	5,923,422	19,873,501
1958	10,748,603	3,811,408	6,033,045	20,593,056

* Data supplied by Dr. Pietro Cova, Direttore Generale, Administrazioni Antonoma dei Monopoli di Stato Italiano, Rome, Italy.

Tobacco production in Syria, Iran, Iraq, and Lebanon

The annual production of aromatic tobaccos in each of these countries is small and of a quality not sought in export markets. Definite figures for the quantities produced by each of them are lacking, but

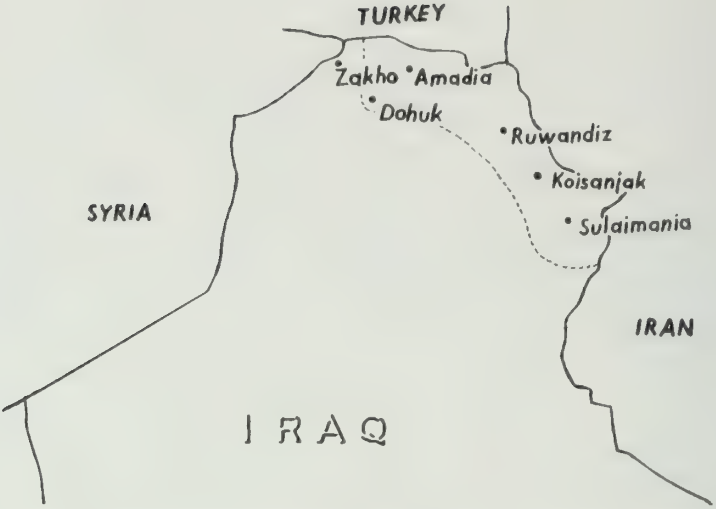

FIG. 15. Aromatic-tobacco-producing area of Iraq and principal marketing centers.

probably they do not exceed 4 to 5 million pounds. The varieties grown originated from the Samsun, Bafra, Trabzon, and Izmir varieties of Turkey and the Basma kinds from Greece. Latakia, a fire-cured oriental kind used in certain blended cigarettes, was formerly grown in Syria and in Cyprus, but is no longer in demand in the United States, France, Italy, and Sweden.

Tobacco production in Libya, the Union of South Africa, and the Federation of Rhodesia and Nyasaland

No doubt two reasons account for attempts in recent years to grow aromatic tobaccos in regions remote from the Near East, namely, scientific curiosity and the rising tide of nationalism. An account of these attempts in Africa, and of the difficulties, frustrations, and successes, is to be found in reports by Brown (1948), Stella (1909, 1913), Taylor (1921, 1924), Van Wyk (1932), Strydom (1944), and Akehurst (1954). When aromatic tobacco was first grown in the Western Province, Union of South Africa, in 1907 the total production was about 3000 lbs. Production increased gradually so that twenty years later the crop amounted to 1.5 million pounds. Libya now produces approximately 650,000 pounds, the Union of South Africa about 1.5 million pounds, and the Federation of Rhodesia and Nyasaland about 1.5 million pounds annually. During 1958 a few plantings were made in Tanganyika.

The Perustitza variety is being grown in Libya. Ayasolouk, among the numerous varieties tested, appears to be most suited for growth in the southern part of Africa. The climate and soil of these South African countries appear to favor suitable leaf size and color of the cured leaf but British manufacturers of cigarettes find aroma and texture quite unlike that of oriental leaf from Greece and Turkey, and hence less desirable. Manufacturers can tolerate a small proportion of such leaf. The future of the aromatic tobacco industry in southern Africa, however, appears to depend to a large extent upon cost of production and market price of the leaf.

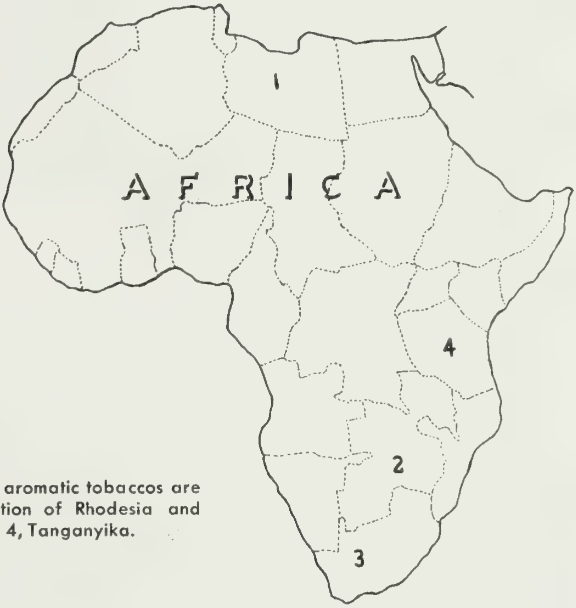

FIG. 16. Countries of Africa in which aromatic tobaccos are being grown. 1, Libya; 2, Federation of Rhodesia and Nyasaland; 3, Union of South Africa; 4, Tanganyika.

Tobacco production in Venezuela

The first attempts to grow aromatic tobaccos in Venezuela were made in 1947. These trials and subsequent ones were conducted at a number of places in the states of Carabobo, Guárico, and Arágua, the planting being made on high *vega* soils of lateritic origin. Varieties belonging to the Xanthi, Kavala, Samsun, and Smyrna types

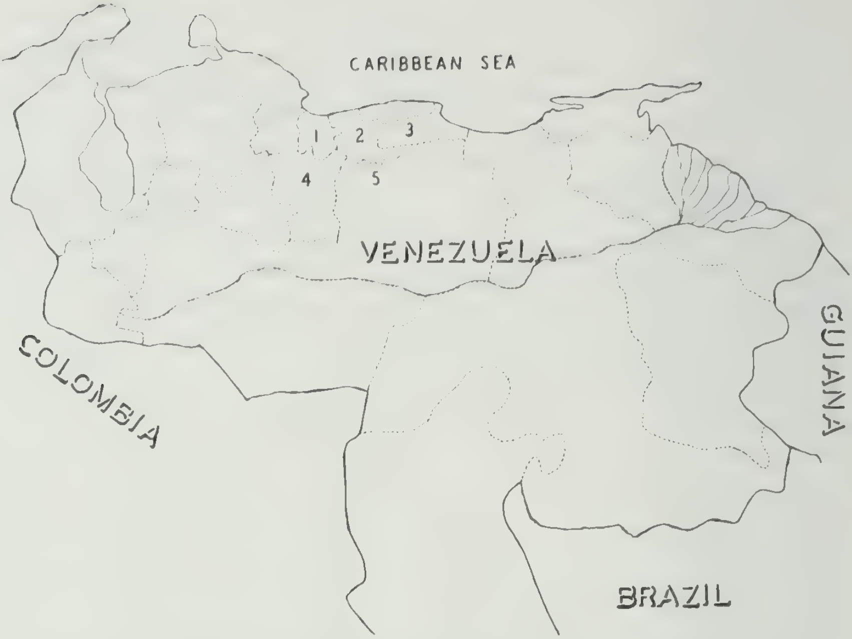

FIG. 17. States of Venezuela in which aromatic tobaccos are being grown: 1, Carobobo; 2, Aragua; 3, Miranda; 4, Cojedes; 5, Guarico.

were included in the trials. Since the tobacco crops there must be grown during the dry season, it is necessary to employ irrigation throughout the growing period. The plantings were made under the supervision of Greek immigrants with experience in growing tobacco in Greece but lacking experience in the use of irrigation. Moreover it was necessary to use mineral fertilizer, a practice not employed in Greece. As a consequence the aroma and texture of the cured leaf were not satisfactory, although such characteristics as color, specific weight, combustibility, and leaf size were acceptable. In most cases facilities for harvesting and curing were inadequate, with consequent prohibitively high cost of production.

These difficulties have been found to be surmountable to such a degree that very good aromatic tobacco is now being produced. Lateritic soils, present in abundance, are highly suitable for this type of tobacco. Proper irrigation practices will gradually be learned. Weather conditions appear to be ideal for curing on racks in open air or under a protective roof. Production presently falls far short of the needs of manufacturers of cigarettes in Venezuela but the prospect exists that in the near future considerable quantities of leaf of good quality will be produced. At present total annual production ranges between 25 and 50 thousand kilograms.

Tobacco production in the United States

The first attempts to grow aromatic tobacco in the United States were made about fifty years ago in Kentucky and California. Published accounts of the work in Kentucky are lacking, but a report by Clarke (1923) details the results of studies made in California. Plantings were made by farmers, Greek and Armenian, who had grown tobacco in the Near East. These first plantings were made near the towns Exeter and Yettem, using the varieties Samsun, Kavala, Bafra, Smyrna, and Dubek. The quality of the leaf grown stimulated the making of trial plantings in other parts of California so that during the course of about fifteen years plantings were made in the following counties: Contra Costa, Fresno, Los Angeles, Napa, Placer, Sacramento, San Benito, Santa Cruz, San Diego, San Joaquin, Stanislaus, Tulare, and Yolo. It was decided, primarily for economic reasons, to abandon further studies

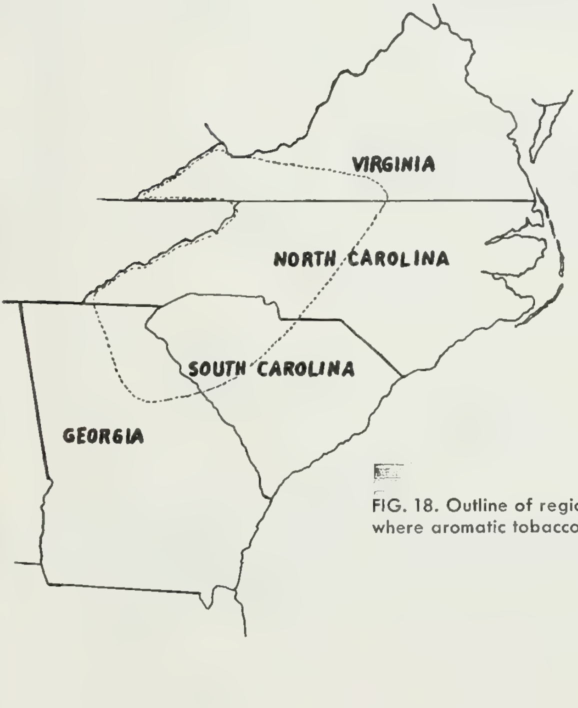

FIG. 18. Outline of region in the southeastern United States where aromatic tobaccos are being grown.

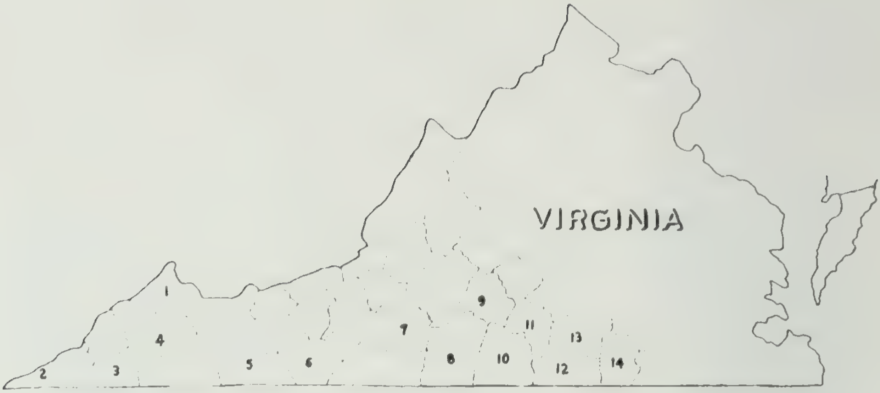

FIG. 19. Location and names of counties of Virginia in which aromatic tobacco has been produced: 1, Buchanan; 2, Lee; 3, Scott; 4, Grayson; 5, Smyth; 6, Carrol; 7, Franklin; 8, Pittsylvania; 9, Campbell; 10, Halifax; 11, Charlotte; 12, Mecklenburg; 13, Lunenburg; 14, Brunswick.

of the production of aromatic tobaccos. More recently further attempts to grow the crop have been made, employing mechanization to reduce the cost of production, but again without success.

In 1939 studies of the nature of aromatic tobacco and the conditions for its growth were undertaken at Duke University. Experimental plantings were first made in fields at the Tobacco Experiment Station, Oxford, North Carolina. Afterward the crop was planted on several farms in Virginia, South Carolina, and North Carolina, and at the Tobacco Experiment Station, Chatham, Virginia, and at Clemson Col-

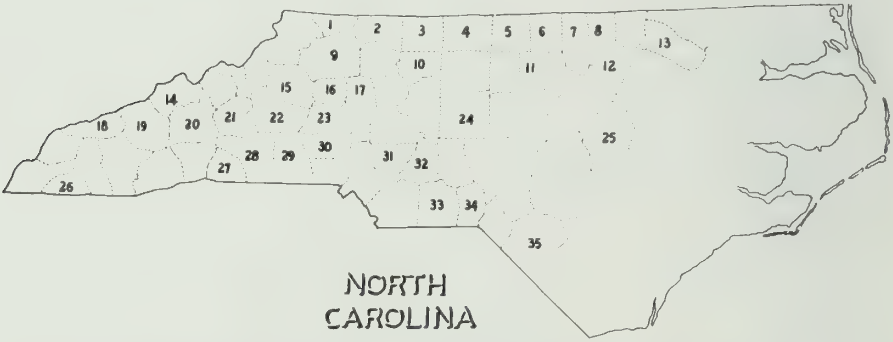

FIG. 20. Location and names of counties of North Carolina in which aromatic tobacco has been produced: 1, Alleghany; 2, Surry; 3, Stokes; 4, Rockingham; 5, Caswell; 6, Person; 7, Granville; 8, Vance; 9, Wilkes; 10, Forsyth; 11, Orange; 12, Franklin; 13, Halifax; 14, Madison; 15, Caldwell; 16, Alexander; 17, Iredell; 18, Swain; 19, Haywood; 20, Buncombe; 21, McDowell; 22, Burke; 23, Catawba; 24, Randolph; 25, Johnson; 26, Clay; 27, Polk; 28, Rutherford; 29, Cleveland; 30, Lincoln; 31, Cabarrus; 32, Stanley; 33, Anson; 34, Richmond; 35, Robeson.

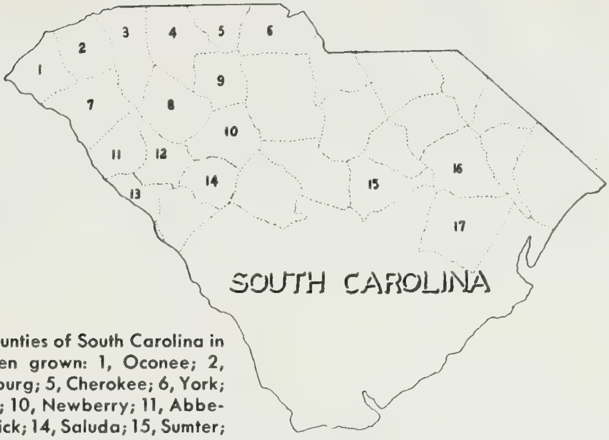

FIG. 21. Location and names of counties of South Carolina in which aromatic tobacco has been grown: 1, Oconee; 2, Pickens; 3, Greenville; 4, Spartanburg; 5, Cherokee; 6, York; 7, Anderson; 8, Laurens; 9, Union; 10, Newberry; 11, Abbeville; 12, Greenwood; 13, McCormick; 14, Saluda; 15, Sumter; 16, Florence; 17, Williamsburg.

lege, Clemson, South Carolina. Certain results of these studies are recorded in a report by Darkis and Mattison (1947). Results of other studies published by the writer that bear mainly on the structure and development of aromatic kinds of tobacco are summarized in Chapters III and IV. Field trials to determine their suitability to conditions of soil and climate in the southeastern United States have been made with approximately seventy-five name varieties, using seed sent from Bulgaria, Greece, and Turkey. A few varieties from each of the four groups of oriental tobaccos have been found to yield leaf of good quality. These include Yaka, Stanimaka, Kavala, Samsun, Smyrna, and Ayasolouk.

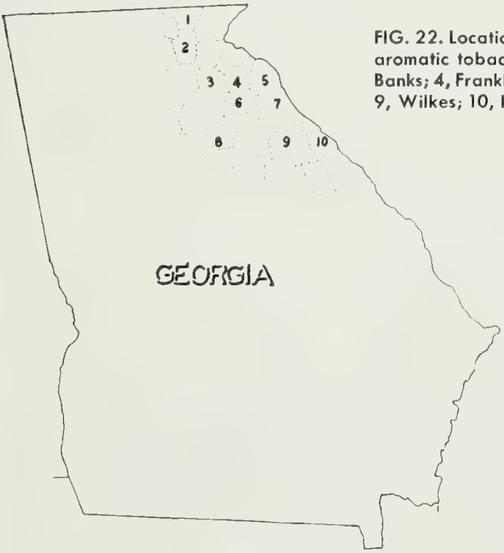

FIG. 22. Location and names of counties in Georgia in which aromatic tobacco has been grown: 1, Towns; 2, White; 3, Banks; 4, Franklin; 5, Hart; 6, Madison; 7, Elbert; 8, Oconee; 9, Wilkes; 10, Lincoln.

Plantings of one or more of these varieties have been made in ten counties in Georgia, seventeen counties in South Carolina, thirty-five in North Carolina, fourteen in Virginia, and five in Kentucky. The purpose of some of these plantings was to learn in which areas and under what climatic conditions aromatic leaf could be grown. In general, the clay soils of the Piedmont region have been found most suitable. To date total annual production remains a few hundred thousand pounds.

Summary

Aromatic tobaccos are being grown in Bulgaria, Cyprus, the Federation of Rhodesia and Nyasaland, Greece, Hungary, Libya, Iraq, Iran, Italy, Lebanon, Pakistan, the Philippine Islands, Rumania, Syria, Tanganyika, Turkey, the Union of South Africa, the United States, the U.S.S.R., Yugoslavia, and Venezuela. The exporting countries are mainly Turkey, Greece, Bulgaria, and Yugoslavia, which together supply to international trade about three-quarters of a billion pounds, or over one-fourth of the total world's exports of tobacco.

Tobaccos of the aromatic type comprise about one-eighth of all kinds of tobacco grown in the world.

A barter system or bilateral trade agreement between the exporting country and the importing one is widely operative in the international distribution of aromatic tobaccos.

There has been a gradual increase in production of aromatic tobaccos in recent years with a correlated increase in demand for blended cigarettes containing in the mixture of tobaccos a proportion of aromatic tobaccos.

European countries, especially, are using increasing amounts of the lower grades of aromatic tobacco in cigarette manufacture instead of flue-cured tobaccos.

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Chapter Three

THE TOBACCO PLANT: RELATIONSHIP, STRUCTURE, AND DEVELOPMENT

A background of knowledge of the relationship, structure, and development of the tobacco plant is essential to an understanding of the characteristics that distinguish aromatic tobaccos from those of other types. It should be appreciated that a considerable proportion of such knowledge has been provided by studies involving types other than aromatic tobacco, but this fact in no wise detracts from its usefulness. At the Tobacco Institute, Cevizli-Maltepe, Turkey, careful studies of the anatomy of leaves and stems of certain aromatic kinds, especially Izmir 64, Basma, and Trabzon, were made by Arsan (1946, 1947, 1949) and Elgin (1951).

Familial relations

The genus *Nicotiana*, which now includes 60 species, according to Goodspeed (1954), was established by Linnaeus, in 1754 in *Genera Plantarum*. At that time it included only four species, namely *N. glutinosa*, *N. paniculata*, *N. rustica*, and *N. tabacum*. Previously other generic names had been applied, and subsequently about a dozen other generic names were given to species of *Nicotiana*. The genus is a member of the nightshade family, Solanaceae, which is constituted of 85 genera and in excess of 2000 species.

The most familiar related cultigens are Irish potato, tomato, pepper, and eggplant. In this family belong also the drug plants henbane (*Hyocyamus*), belladonna (*Atropa*), and jimson weed (*Datura*), and such garden flowers as petunia and salpiglossis.

Features of Nicotiana

Most of the species of *Nicotiana* are herbaceous annuals, a few are perennials, and two species are soft woody shrubs. *N. tabacum* is grown as an annual in nearly all areas where it is cultivated, but in tropical regions it is perennial. If the stem is severed near the soil surface at the end of harvest, a sucker will form and may grow to bear harvestable leaves. Tobacco requires a growing season of approximately six months from the time of sowing the seed to the time of maturity of a new crop of seed. The stems are characteristically unbranched, the leaves are alternately arranged, the inflorescence is a terminal panicle, and the tiny seed are borne in two-lobed capsules.

The root system—Most of the studies made of the root systems of tobacco have been concerned primarily with modifications resulting from different fertilizer practices, from the influence of depth of plowing, and from the effects of root diseases and attacks by nematodes. Among the few investigations concerned with the root system of tobacco per se that of Popovici (1896) is among the earliest. He used two aromatic varieties, Yaka and Samsun, and found that roots of both were confined to the upper soil layer to a depth of 30 cm. Also he noted that Yaka has a poorly developed root system whereas the roots of Samsun are well developed, much branched, and more completely fill the soil. Such existence of varietal differences among aromatic tobaccos in extent of root systems has been confirmed in all subsequent studies.

Bruner (1932), by making a trench and carefully washing out the roots, found that the root system of a single tobacco plant may occupy an area 9 feet in diameter and may extend to a depth of 5 feet.

Piescu (1938) used wooden boxes in which to plant several different varieties, including Yaka, Molovata, Rezina, Ghimpatzi, Banat, Ialomitza Sătmărean, Gaĕste, and Samsun. The dimensions of the boxes were 90 cm. long, 3 cm. wide, and 90 cm. deep. They were filled with a 1:1 mixture of field soil and sand. The roots of all of the varieties extended to the bottom of the boxes and all occupied completely the available soil space in similar fashion. When these varieties were planted in the field he found that 76% of the roots, on the basis of weight, occurred in the upper 20 cm. layer. The ratio of weight of above-ground parts to that of the root system was within the range 3:1 to 4:1.

Gier (1940) studied the root system of flue-cured tobacco grown in sandy soils of the Coastal Plain of North Carolina. As is well appreciated, the tap root is broken when tobacco is transplanted and the roots formed thereafter are mostly adventitious. In fact, he showed that approximately 72% of the roots are adventitious. The roots of plants ranged in total length from 260 to 432 meters. Under field conditions the shoot-root ratio, by weight, averaged approximately 10:1.

Koch (1922) advocated that deep plowing of soils planted to aromatic tobacco in South Africa encouraged root penetration and aided the crop to withstand dry weather. A similar relationship between depth of plowing and occupancy of the soil by the roots of cigar tobacco in Connecticut was established by de Roo (1957).

Stalk or stem—The unbranched stalks or stems of oriental varieties of tobacco have the shape of a gradually tapering cylinder, being largest at the base. They consist of a series of nodes and internodes, a single leaf being borne at each node and with one or two dormant buds borne in the axil of each leaf. The stalk elongates by apical growth and finally is terminated by the inflorescence. The stems vary in length from 2 to 10 feet depending upon the variety, the availability of water and mineral nutrients, and light conditions. The axillary buds tend to remain dormant unless the inflorescence is removed. The internodes tend to become progressively longer and of greater weight from the basal one upward toward the middle of the stalk. They then become progressively shorter and lighter to the uppermost one.

Esau (1938) made a study of the structure of mature tobacco stems, particularly of the vascular tissues. She noted that the internode in transverse section has three regions, (*a*) an outer region, the cortex; (*b*) a central region, the pith; and (*c*) between these, the vascular region. The cortex consists almost wholly of chlorophyll-bearing parenchyma tissue. The pith consists of large, colorless thin-walled parenchyma cells. The vascular tissue is a continuous ring of xylem (woody, water-conducting cells) that is separated from the external phloem (food-conducting cells) by cambium (embryonic cells). Around the periphery of the pith and adjacent to the primary xylem is the internal phloem. The external phloem consists of groups of sieve tubes and companion cells interspersed with small parenchyma cells. These groups, in turn, are separated by large parenchyma cells that lie along the same radius as the cells of the xylem, and they are aptly termed "primary" rays. The types of cells of which Izmir 64 stems are composed are illustrated in the account by Elgin (1951).

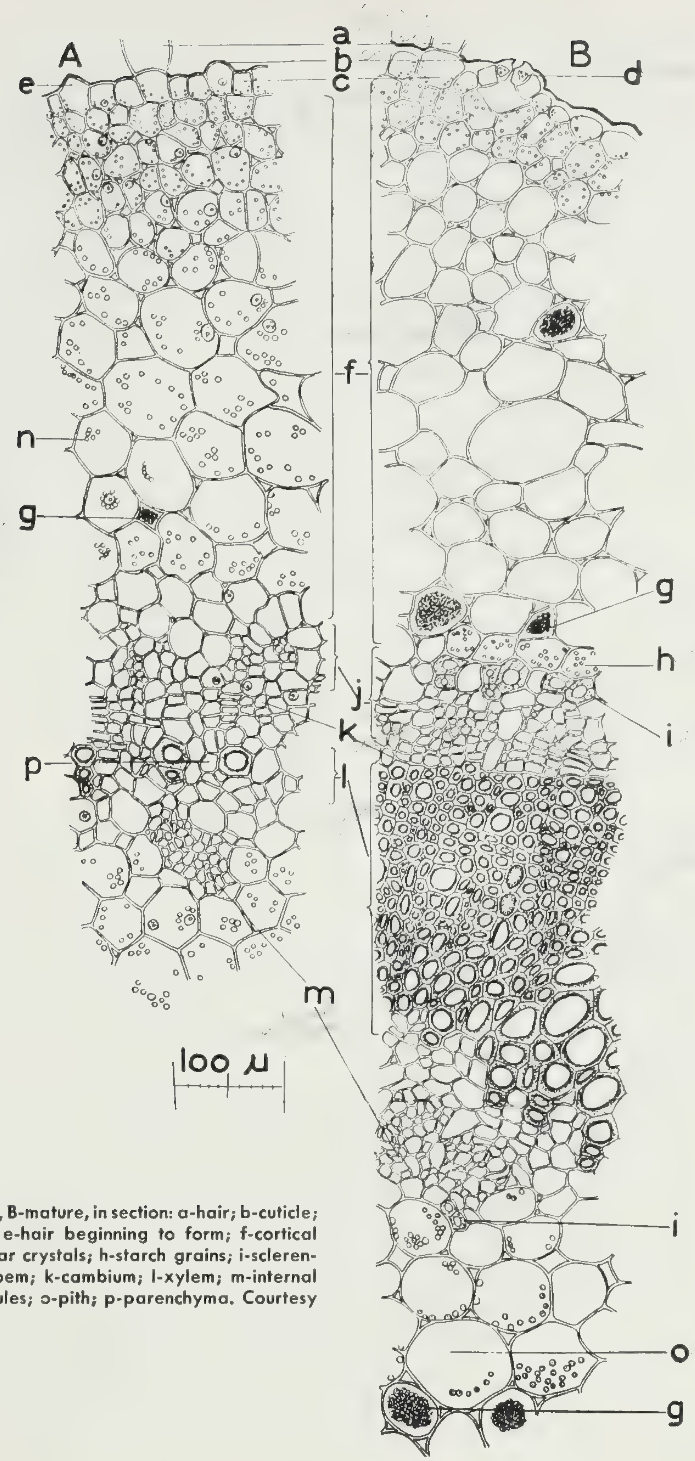


FIG. 23. Stem: A-young, B-mature, in section: a-hair; b-cuticle; c-epidermis; d-stoma; e-hair beginning to form; f-cortical parenchyma; g-granular crystals; h-starch grains; i-sclerenchyma; j-external phloem; k-cambium; l-xylem; m-internal phloem; n-starch granules; o-pith; p-parenchyma. Courtesy N. Elgin, 1951.

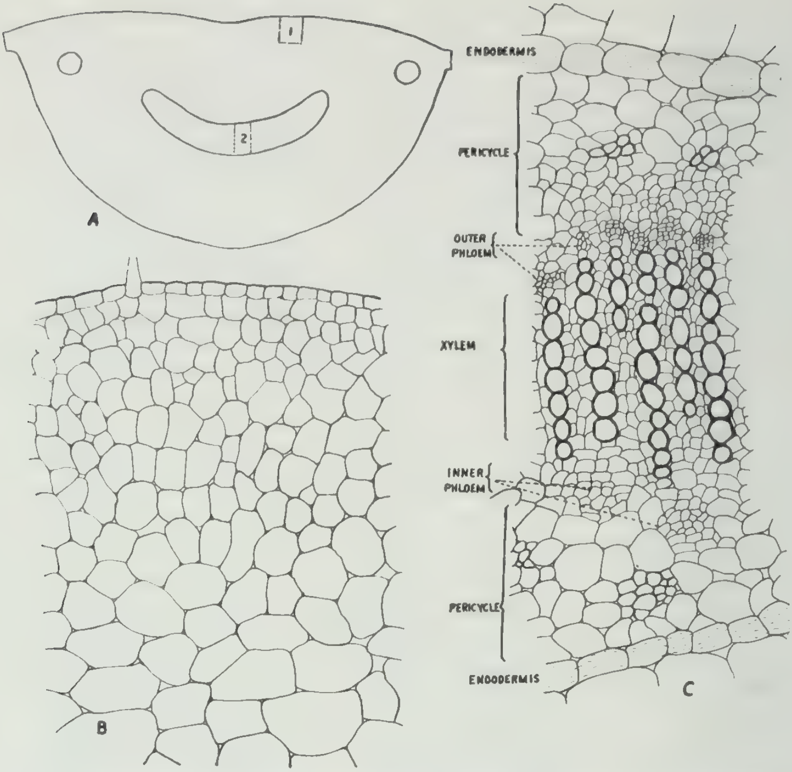


FIG. 24. Midrib of tobacco leaf: A-cross section in outline; B-parenchyma tissue of region shown in 1, in A; C-cross section of region shown in 2, in A, showing vascular tissues.

In the same transverse section one may see a leaf trace, the cross section of a branch of the vascular cylinder. One branch extends into each leaf midrib. There it appears as a single, crescent-shaped, vascular bundle with the phloem practically completely surrounded by xylem.

The leaves—Leaf shape, among aromatic tobacco varieties, is extremely variable, being broadly elliptic, lanceolate, deltoid, or narrowly elongate (*sirdilli*). The tip may be blunt or acute. The leaves may be broadly attached to the stem, narrowly attached, or petiolate. The petiole may be bare or be provided with frill-like wings (*koulaksis*). There may be rounded auricles at the leaf bases (*kabakoulak*), or the wings may extend down along the stem. Leaf shape is one of the characteristics of a given variety, and is a heritable feature.

The leaves are arranged patternwise, one at each node along the stem. They occur alternately as an ascending spiral that is either clockwise or counterclockwise in direction. As the spiral progresses upward it will be found that in most varieties of tobacco the eighth leaf or the thirteenth leaf will be directly above the first leaf considered in counting. Note should also be taken of the number of times the spiral passes around the stalk before reaching the eighth leaf or the thirteenth leaf. It will be found that the spiral has encircled the stem three times when the eighth leaf stands above the first one counted, and that five encirclements are made when the thirteenth leaf stands directly above the first one counted. Leaf arrangement is called phyllotaxy, and is expressed as a fraction. The number of encirclements is the numerator and the number of leaves counted to find the one that stands directly above the first one counted is the denominator. In the foregoing cases then, the fractions would be $3/8$ and $5/13$, respectively.

It is widely appreciated that the direction of the spiral pattern of leaf arrangement is clockwise in some plants and counterclockwise in others. Allard (1946) found in *Nicotiana tabacum* and *N. rustica* that the individual characteristics of spirality are not transmitted from parent to progeny. His studies involved the sampling of 23,057 plants. The distribution of clockwise spirality and counterclockwise spirality in this population was subjected to Chi-square tests to determine the significance of results as to their goodness of fit. As a result, the Chi-square values indicated that the samples were taken from a plant population having a 50/50 ratio of clockwise ones to counterclockwise ones.

An account of events that occur during the development of leaves by tobacco was given more than twenty-five years ago by Avery (1933). He noted that each leaf originates as a lateral projection from the growing points of the stem. The growing point is characteristically at the apex of the stem but additionally one or two growing points are found in the axil of each leaf. This lateral projection from the apex is at first shaped like an elongated cone. It consists mostly of primordium of the midrib but by the time that it is about one mm. long, two lateral flaps will have developed, one on each side of the midrib. These flaps will become the leaf blade or lamina. They are initiated by a row of marginal cells just beneath the epidermis or outer layer. The row extends along on opposite sides of the midrib and Avery (1933) designated it "marginal meristem." The new cells that arise by division of this marginal meristem are mother palisade parenchyma or mother spongy parenchyma, as determined by the plane of division of the

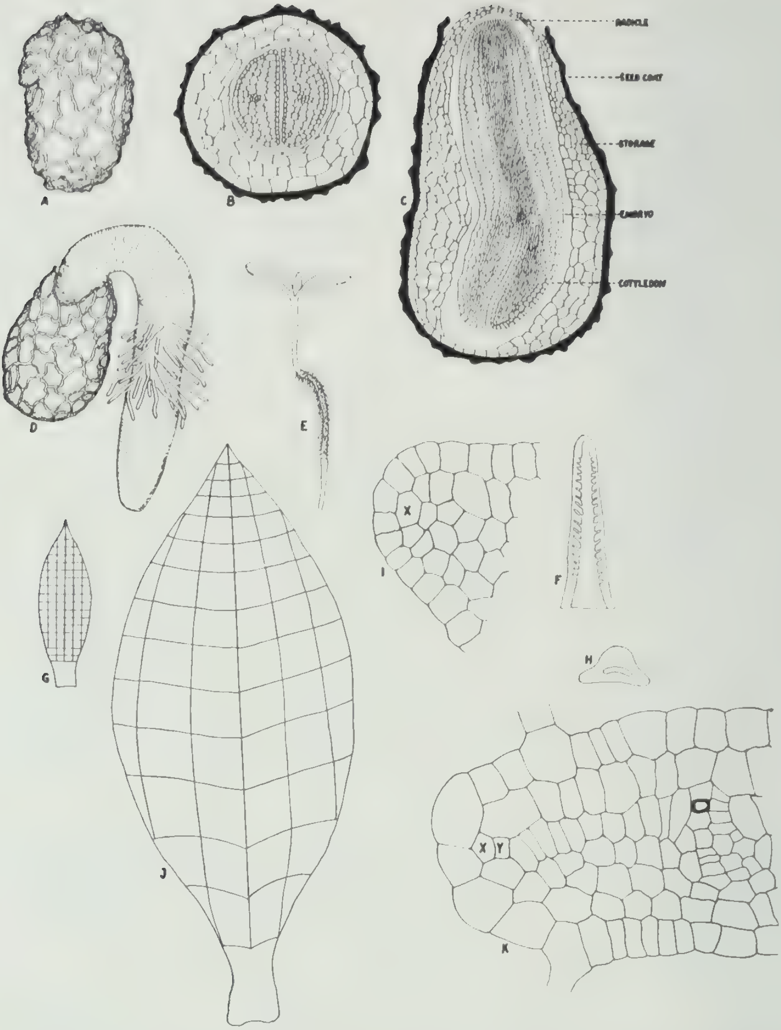


FIG. 25. Structure of tobacco seed, germination of seed, and leaf development. A-Surface view of tobacco seed; B-cross section of tobacco seed; C-longitudinal section of germinating seed in an early stage showing the structural parts; D-young seedling about 24 hours older than that shown in C; E-week-old tobacco seedling; F-young leaf at time when it is principally midrib; G-young leaf ruled into equal areas by use of ink; H-cross section of young leaf at stage in which flaps of blade are forming on each side of the midrib; I-cross section of young blade showing at X "marginal meristem" cell; J-expanding leaf; compare with leaf shown in G; K-marginal meristem cell has divided to form X and Y, that will become palisade and spongy parenchyma cells respectively. Figures F, G, H, I, J, K courtesy G. S. Avery, 1933.

marginal meristem. By the time that the leaf is about one-thirtieth of its mature size, cell division ceases near the tip of the developing leaf, but the marginal meristem along the leaf edges and base continues to divide until the leaf is approximately one-fifth to one-fourth its mature size. Nearly all further increase in size of the leaf after it attains this stage is the result of expansion of cells already formed. Meantime epidermal cells are giving rise to more epidermal cells and, in this way, as the leaf increases in size, provide the outer covering of the leaf. The stress on the epidermis from expansion of the palisade parenchyma and spongy parenchyma causes the epidermal cells to be distorted, in consequence of which their walls are wavy or flexuous. This feature can best be seen by stripping off the epidermis and viewing it perpendicularly to the leaf surface, by use of a microscope.

The absolute rate of growth of the marginal meristem varies and the rate of expansion of the resultant cells governs the final shape of the leaf. But, as pointed out, this rate differs in different regions of the leaf. Why there should be this regional difference in growth rate

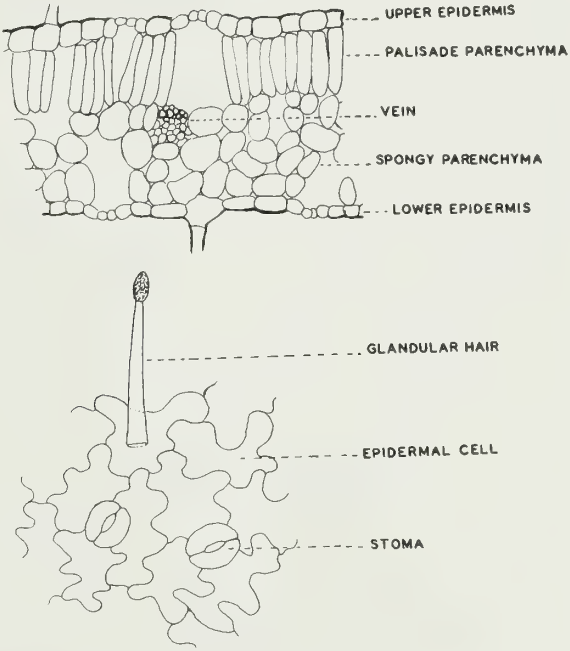


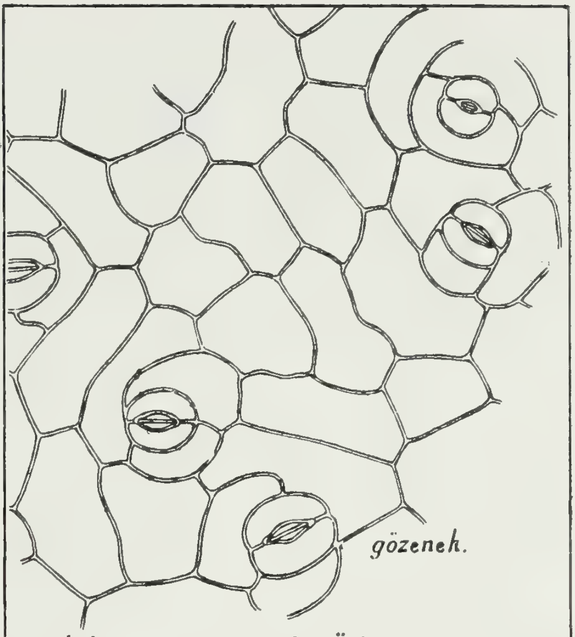
FIG. 26. Leaf tissues of mature leaf in cross section, top, and surface view of epidermis showing stomata and glandular hair, bottom.

is wholly unknown. A period of 20-24 days is required for the growth and expansion of a leaf from the time that it is a cone-shaped primordium to the time when it is fully grown.

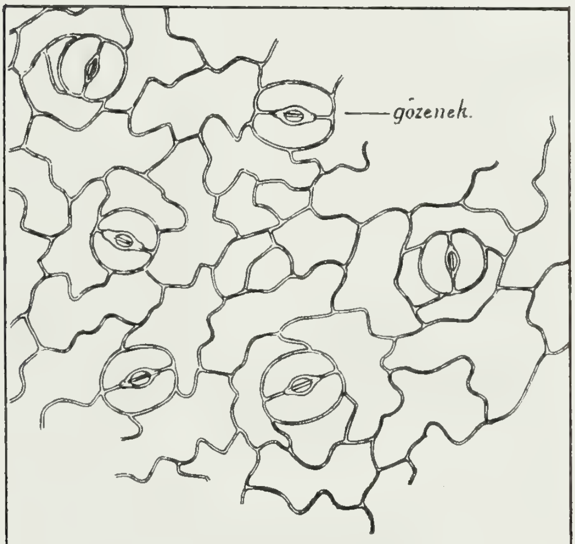
By examination of vertical sections of leaves it may be seen that, aside from the veins, they are composed of the following tissues: upper epidermis, having stomata and ordinary epidermal cells some of which are modified to become the glandular and non-glandular hairs or trichomes; palisade parenchyma, containing chlorophyll; spongy parenchyma, the cells of which are loosely arranged and bear chlorophyll; and the lower epidermis, consisting of stomata and ordinary epidermal cells, some bearing trichomes. The anatomical studies by Arsan (1946, 1947, 1949) of leaf hairs, stomata, epidermal cells, and chlorophyll-bearing cells show the features of these constituent tissues. He found that the upper epidermal cells of Izmir 64 are larger, the stomata are larger, and their walls more undulate than those of the lower epidermis. Elgin (1951) found 40 stomata per mm.^{2} on the upper surface and 182 per mm.^{2} on the lower leaf surface.

Flowers and capsules—The flowers of aromatic varieties of tobacco are arranged in a loose terminal panicle. Each flower is about 5 cm. (2 inches) long. Their color is pink, although some varieties tend to be carmine. Each one is borne on a short pedicel. The petals are united into a tube that expands above to become funnel-shaped. When viewed from above the corolla is rotate with five recurved lobes. The calyx is green, five-cleft, much shorter than the corolla, and it persists permanently, surrounding the base of the capsule. The five unequal separate stamens are attached near the base of the corolla tube, their point of attachment being on the midvein of each petal. The stem of each stamen is known as the filament and bears apically a two-lobed anther that contains the pollen. At maturity the wall of each anther splits longitudinally and the pollen is liberated through the fissures thus formed. The pollen grains adhere in clumps. Each grain is a sphere and the wall is provided with three pores through any one of which the pollen grain germinates by formation of a pollen tube.

The ovary, which eventually becomes the capsule containing the seeds, is bilocular. It is seated on a disc-like, thick, nectar-bearing base that is enclosed within the base of the calyx. A slender style extends beyond the corolla tube and expands apically into a bulbous stigma that is medianly grooved. At maturity the surface of the stigma be-



Şekil: 1. Basma Sortu, Üst Deri Doku.



Şekil: 2. Basma Sortu, Alt Deri Doku.

FIG. 27. Upper and lower epidermis of Basma showing differences in size of stomata and epidermal cells. Courtesy E. N. Arsan, 1946.

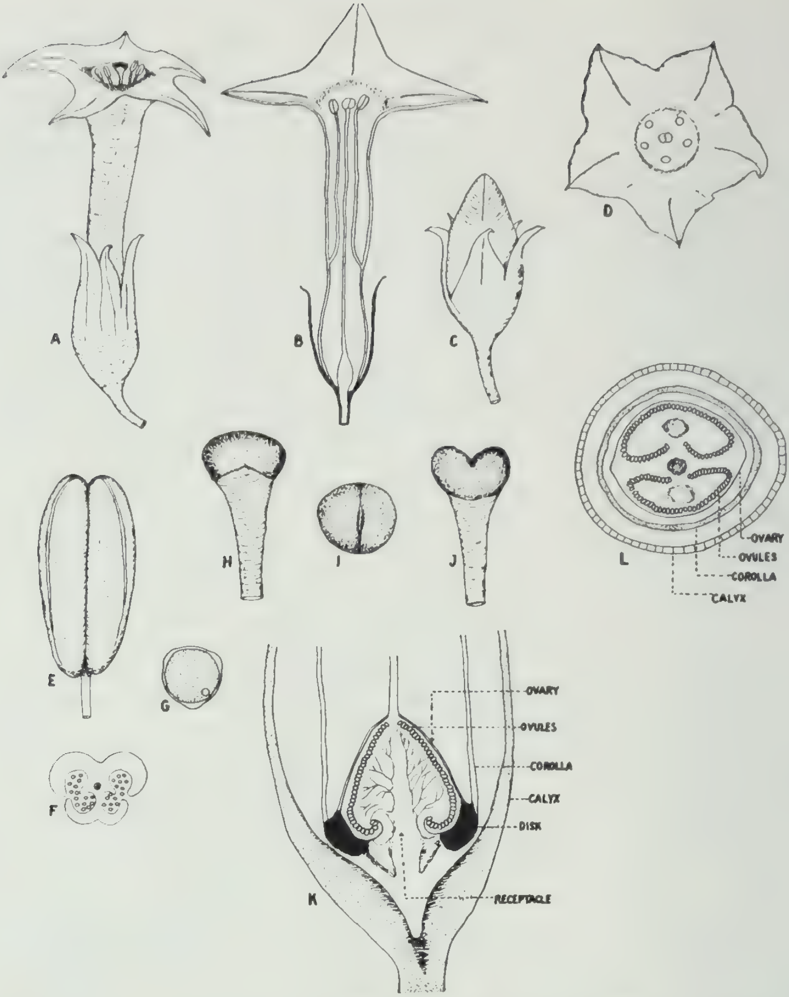


FIG. 28. Parts of tobacco flower: A-entire flower; B-flower split lengthwise; C-capsule; D-flower as seen from above; E-two-lobed anther; F-cross section of anther, in outline; G-pollen; H, I, J-stigma as viewed from side, above, and front, respectively; K-base of tobacco flower in longitudinal section to show position of parts; L-cross section of capsule, showing position of parts.

comes sticky, aiding the pollen to adhere. Pollen is liberated at the time that the stigma is sticky, providing for self-fertilization. The pollen tube grows down within the tissue of the stigma and style to liberate the two sperm cells of the pollen tube into an embryo sac of the young ovule. One sperm cell then unites with an egg cell and the other with a cell from which the endosperm develops. This entire process beginning with pollination and ending with the unions, or fertilization, requires a period of about forty-eight hours. About three to four weeks after fertilization the ovules will have become mature seeds. The ovules are attached at the surface of a cone-shaped, spongy placenta that occurs as a core in each ovary. The capsules split open when the seeds are mature, beginning at the tip of the ovary, thus permitting the minute, kidney-shaped, brown seeds to be scattered. The seed measure approximately 0.75 × 0.50 mm., being so tiny that from 300,000 to 350,000 are required to weigh an ounce. The seed coat becomes wrinkled as the seed dries, giving it a net-like or reticulated appearance. Each capsule contains from 1000 to 3500 seeds.

Seed structure and germination—As bearing on the detailed structure of tobacco seed, Avery (1933) observed that the epidermal cells composing the seed coat have thickened, cuticularized walls, reddish-brown in color. Below the epidermis there are two or three layers of thin-walled cells and beneath them a single layer of nucellar or nurse tissue. The endosperm is a layer several cells thick, consisting of thin-walled, oil-filled cells. Beneath this is the embryo. Its cotyledons possess four layers of cells, covered by a lower and an upper epidermis. At the base of the cotyledons and between them is a tiny cone-shaped group of small cells that constitute the growing point of the stem, the epicotyl.

As soon as the seeds are mature they are capable of germination. They will germinate within a week when sown at the surface of moist soil. Slight swelling is the first evidence that germination has begun. Next the seed coat is ruptured at the end from which the radicle is beginning to emerge. As the process continues, the radicle, which is positively geotropic, extends downward, and the cotyledons expand, and in so doing gradually push off the seedcoat. By this time root hairs have formed in a region distal to the tip of the elongating radicle, and the two cotyledons will have become green. Meantime the tiny epicotyl, the growing point of the stem, will have grown to the extent that it may be easily seen. Given favorable temperature and moisture the seedlings will be established within two weeks after the seed have been sown, and they should be of sufficient size for transplanting five to six weeks later. Normally the lowermost leaves are harvestable fifty to sixty days after transplanting. The duration of the harvesting period is variable, usually extending over a period of five to eight weeks, depending upon the prevailing weather and the variety. The leaves are gathered, as they mature, a few at a time, at intervals of four to seven days. By the time that the capsules arising from the first flowers are mature, the uppermost leaves, that comprise the last ones to be gathered, have reached maturity.

Leaf hairs—Among the highly important structures possessed by species of *Nicotiana* are leaf hairs. They are first evident by the time the leaf primordium is 0.5 mm. long. These leaf hairs are of several types, each species being characterized by the possession of particular kinds of hair. As shown by Goodspeed (1954), leaf hairs therefore, have phyletic significance. He states that the types of hairs on inter-

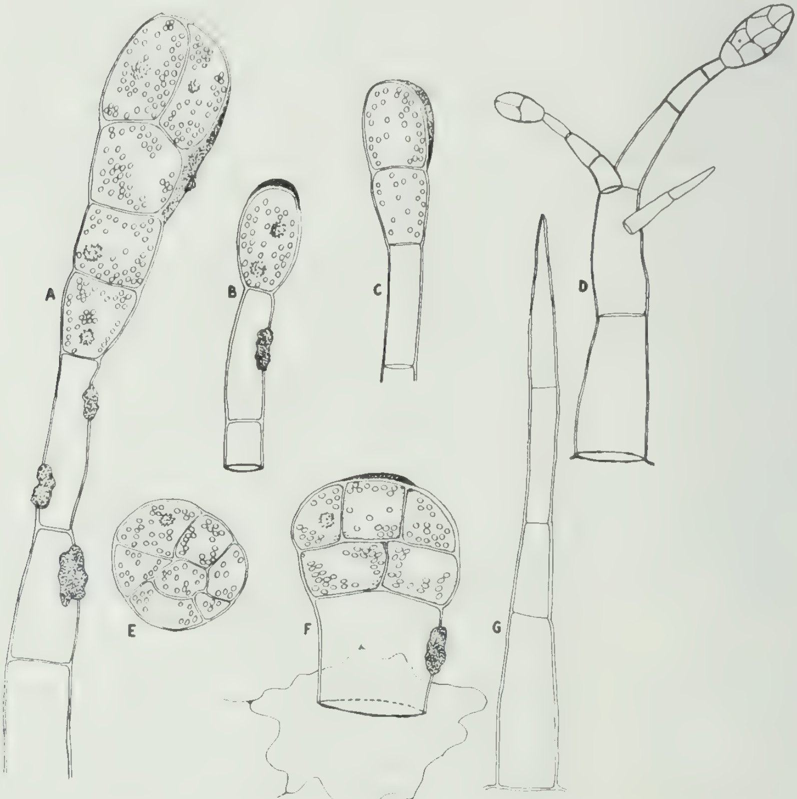


FIG. 29. Trichomes of tobacco: A-glandular trichome with several-celled gland; B-glandular hair having one gland-cell; C-glandular hair having two gland-cells; D-branched glandular hair; E, F-short glandular hair having one stalk cell, as seen from above and laterally, respectively; G-non-glandular hair.

specific hybrids of *Nicotiana tabacum*, and other amphiploid species are heritable. Tanaka (1955) examined the leaf hairs of Japanese varieties of tobaccos. The studies of Bentley and Wolf (1945) emphasize the importance of leaf hairs as a factor in determining quality in aromatic tobaccos.

Hairs are tegumentary appendages, arising on stems, leaves, calyx, capsule wall, etc. In general, they are glandular or else non-glandular, simple or branched. Some glandular hairs are composed of a single stalk cell surmounted by a single spherical or ellipsoidal gland cell. Others consist of a series of three or four stalk cells, tapering upward, and an apical gland cell. The gland cell may remain unicellular or become multicellular by the formation of horizontal walls or of anticlinal and periclinal walls. Alternatively the hairs may be branched, having a gland at each tip.

Because of their activities glandular hairs may properly be regarded as organelles. Chloroplasts are contained in the gland cells, enabling the glands to synthesize, *in situ,* the characteristic, gummy, resinous exudate. Elaboration and excretion of exudate are favored by clear days and hot weather. Crystals or druses are usually present in the glands.

The structure of the leaf hairs may best be seen by microscopic examination of green leaves, using low-power magnification. Such examination requires samples made by stripping off the lower epidermis, it being more difficult to strip off the upper epidermis. The lower epidermis of the leaf may be stripped off by holding the leaf taut over a finger tip of one hand, grasping the edge of the leaf with the other hand, and tearing it toward the midrib or toward the base of the leaf. By this means large strips of lower epidermis may be removed with facility. The strips may then be laid with the outer leaf surface uppermost in a film of water on a microscopic slide. A cover glass should not be applied, for the hairs should be permitted to stand erect.

An appropriate sample will be found to consist of five strips taken from near the leaf base, the tip, and the middle of the leaf. The total number of hairs found in two microscopic fields of each of the five strips may be counted and the average of the ten counts may be regarded as the hair count per microscopic field. The calculation of the number of hairs per lower leaf surface made by Wolf and Brown (1948) was based upon the area of the microscopic field. The computed determination of the leaf size was based upon the weight of a paper pattern made by tracing the outline of the leaf. Then the weight of the paper pattern was compared with that of a standard area of paper of the same kind. By use of this technique, examination of several varieties of aromatic tobaccos was made to determine the population of hairs per unit of leaf area (Wolf and Brown, 1948). Some of their results are shown in Table XI.

It should be indicated that this list contains only a few of the many varieties of which the four fundamental types—Samsun, Izmir (Smyrna), Kavala, and Xanthi—are composed. All were grown in as nearly identical conditions as possible, but the soil factors and climatic factors may have been unfavorable for best growth of certain of them. None of the varieties had been selected in an attempt to produce a uniform or homogeneous population of plants within them. In general, however the varieties of the Xanthi type, from the Macedonian, Thracian, Old Greece, and Aegean Isles regions possessed leaves with the lowest population of glandular hairs. Nevertheless, it is well appreciated that Xanthi tobaccos are superior to those of the other types as regards delicacy and pleasantness of flavor and aroma. Even though the number of hairs per unit area of leaf surface in Xanthi type varieties is less than that of other types, volume of aroma appears to be correlated with hairiness as based upon per unit of leaf surface area.

In fact, volume of aroma was found to be directly correlated with population of glandular hairs per unit-area of leaf surface; i.e., the larger the volume of aroma, the larger the population of glandular hairs. This may be interpreted to mean that quantity of aroma depends entirely upon hairiness. Quantity of aroma must also be related to the amount of exudate that has accumulated on the leaf when it is harvested. Undoubtedly such other factors as compactness of cells constituting the leaf tissue, the amount and kinds of organic and mineral components, the stage of maturity of leaves at time of harvest, and the proper curing and fermentation practices are among the complex of factors that contribute to aroma.

Even though all the leaves on a given plant tend to have the same per-leaf population of hairs and the evidence points to inheritance of degree of hairiness, nevertheless, a range of variation exists. Such occurrence is anticipated since there must be some mechanism that operates during the period when the leaf tissues are being formed that controls the orderliness of design and fixes the ratio among hair-producing epidermal cells, stomata, and other epidermal cells. Evidence

TABLE XI. PER LEAF POPULATION (LOWER SURFACE) OF GLANDULAR HAIRS OF ORIENTAL TOBACCOS WHEN GROWN IN NORTH CAROLINA

Varietal name	*District from which seed came*	*Average per leaf population of hairs (thousand)*
Stanimaka	Macedonian Bulgaria	152.0
Stob	Macedonian Bulgaria	143.4
Goli Ruchki	Macedonian Bulgaria	140.1
Ustina	Southern Bulgaria	181.8
Ghimpatzi	Southern Bulgaria	243.4
Molovata	Southern Bulgaria	227.9
Akhisar	Akhisar	141.7
Izmir Carorköy	Akhisar	195.8
Izmir Akhisar	Akhisar	170.2
Ghiavourköy	Smyrna	159.6
Ayasolouk	Smyrna	183.2
Smyrna	Smyrna	245.0
Djanik	Bafra-Samson	127.2
Samsun	Bafra-Samson	259.2
Dere	Bafra-Samson	255.7
Maden	Maden-Dere	89.4
Dere	Maden-Dere	137.9
Dere-Gudekli	Maden-Dere	134.3
Maden-Dergeris	Maden-Dere	159.1
Myrodata de Samos	Aegean Isles	134.9
Myrodata Agrinion	Agrinion	234.7
Argos	Argos	205.9
Sari de Almyros	Volos	201.6
Mavra de Lamia	Volos	107.1
Mavra de Thessalia	Volos	91.1
Kabakulak de Poroj	Poroj	93.6
Alistra Zichna	Zichna	98.1
Razoliva Zichna	Zichna	96.7
Kuproköy	Zichna	95.3
Zilachova Zichna	Zichna	100.4
Canalia Zichna	Zichna	102.1
Nikisian Pravista	Zichna	127.9
Bashi Bagli de Prosotsani	Prosotsan	121.9
Veznik Serres	Serres-Yaka	107.6
Soubasköy Serres	Serres-Yaka	93.6
Basma de Serres	Serres-Yaka	141.6
Nusrali Mahala	Mahala	82.3
Nigrita Mahala	Mahala	97.6
Basma de Mahala	Mahala	98.8
Kiredzilar	Djebel-Xanthi	78.9
Basma de Xanthi	Djebel-Xanthi	129.3
Karchi Yaka	Djebel-Xanthi	85.5
Avli Pravista	Pravista-Kavala	126.3
Podogorian Pravista	Pravista-Kavala	110.3
Balustra Biarkolou	Xanthi-Ova	100.6
Doxat	Drama-Basma	100.6
Samsun de Katerini	Saloniki	233.8

bearing on the degree to which hairiness may vary rests partly upon the findings from spacing trials. When plants of the variety Ayasolouk were so spaced that the average leaf surface of widely-spaced ones occupied an area of 254.3 $\mathrm{cm.}^2$ and that of closely-spaced ones 113.5

cm.^{2}, a size ratio of approximately 2.2:1, the average total number of hairs per leaf on the lower leaf surface was found to be 273.7 (thousands) as compared with 198.1 (thousands), a ratio of approximately 1.4:1. Increase in size of leaves does appear, therefore, to be accompanied by a corresponding increase in total per-leaf population of hairs. In fact such discrepancy in ratio was found to become greater if leaf size is increased to the proportions 3:1 or 4:1. In general it may be concluded that hairiness is correlated (1) with time of maturity, early maturing varieties being less hairy than late maturing ones; (2) with leafiness of varieties of low stature having about 20 leaves, these being less hairy than tall varieties that have two or more times as many leaves; and (3) with desirable leaf size, those with large leaves possessing less quality than those with small leaves.

Summary

Essential structural features of the roots, stems, leaves, flowers, capsules, and hairs of *Nicotiana* are described to provide a background for understanding the characteristics of aromatic varieties of tobacco. Varieties differ in the extent of their root systems. The leaves arise from a cone-shaped primordium and require a period of 22-24 days to attain adult size. The formation of new cells ceases by the time the leaves have attained one-fifth to one-fourth their final size. Expansion of cells accounts for subsequent increase in leaf size.

The flowers are self-fertile. Each capsule bears 1000 to 3500 seeds.

The glandular hairs are organelles that produce and excrete gummy, resinous materials which are a primary source of aroma.

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Chapter Four

PHYSIOLOGY OF AROMATIC TOBACCO

It has been asserted that the two most significant recent findings that have been made in studies of the physiology of the tobacco plant are those of Garner and Allard (1920) and Dawson (1942 a,b). Garner and Allard found that the period of vegetative growth and reproduction of tobacco and certain other plant species is conditioned by length of day, which they termed photoperiod. Mammoth varieties of tobacco, for example, were found to continue their vegetative development throughout the entire summer and early fall and could be induced to flower only during the short days of fall and winter. As a result of these studies on the influence of length of day on the initiation of flowering in tobacco investigators have determined that many plant species are long day, others short day, and others are photoperiod neutral.

Dawson (1942 a, b) established that the alkaloid nicotine is synthesized mainly in the roots of tobacco and is transported to the aboveground parts of the plant. In the case of a Turkish variety Dawson (1960) determined that 97% of the total alkaloid content is produced in the root system, whereas less than 1% is formed in the leaves and the remainder in the stem. He also found, by use of excised roots grown in pure culture, that nicotine is synthesized in root cultures, being elaborated in the moving region of the new root tissues. On the other hand, mature tissues of excised roots of *N. glauca* were the loci of the synthesis of anabasine. By supplying the cultures of tobacco roots with hydrogen isotope ring-labeled nicotinic acid and with carbon isotope-labeled amino acids he was able to show that nicotine and anabasine may be synthesized from nicotinic acid and ornithine, and from nicotinic acid and lysine, respectively. Moreover, he grew in culture stem callus tissue of *N. glutinosa* and found the tissues to be entirely free of alkaloids. Interestingly the rate of nicotine biosynthesis in root cultures is directly dependent upon the rate of growth of the root tissues. Even though this correlation has been established, the function of Nicotiana alkaloids and their utilization by the plants themselves remains conjectural.

So numerous have been the investigations dealing with the physiology of the tobacco plant that one who attempts to assemble and interpret them is simply frustrated with an overwhelming sense of inadequacy to carry out such an undertaking. In part because of this feeling, the writer elected to limit this discussion to correlated structure and function as they apply to the successful production of aromatic tobacco.

Growth rate

Many studies have been made that involve the rate of growth of different species of animals and plants. When rate of growth is measured and plotted against elapsed time, the sequence of events designated growth rate of all kinds of organisms may be portrayed as an S-shaped or sigmoidal curve. Such a curve expresses the fact that the rate of growth gradually increases during the early stages of development to a maximum, after which, with the approach of maturity, there is a gradual decline in rate of growth to the time that growth stops. No adequate explanation for such changes in growth rate appears ever to have been made. Such as have been made were well evaluated by Glaser (1938), who stated, "When reduced to absolute dryness, a fair sample of the literature on organic growth yields a residue in which a few volatile platitudes are embedded in a voluminous matrix of quantitative fact."

In quest of an explanation for the changes in rate of growth of aromatic tobacco the writer (Wolf, 1947) made use of two groups of field-grown Smyrna tobacco plants. All plants of one group were decapitated or topped (removal of the inflorescence) as soon as the floral axes had appeared, and their leaves were harvested as they matured. The plants of the other group remained unmolested; i.e., they were neither topped nor harvested. A series of weighings was made of the plants in each group, using, as growth increments, the combined fresh weight of internode and the leaf belonging to that internode. The comparable cumulative weights of each of the two groups of plants are shown in Fig. 30, the weight of each successive segment being combined with that of all of the segments that had formed basally. By so

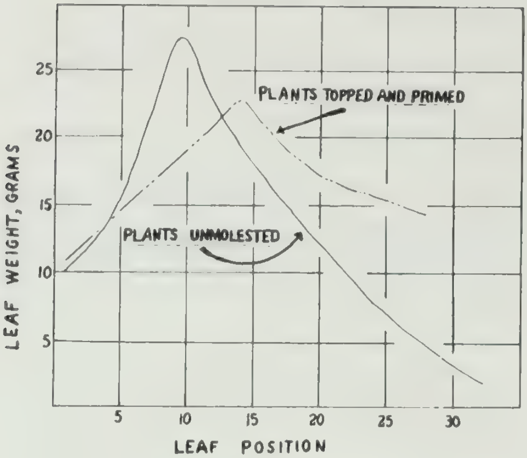

FIG. 30. Comparison of non-topped and topped aromatic tobacco plants as to stalk position and size of the largest leaf to show imbalance between "vegetativeness" and "flowering and fruiting" induced by topping.

doing it may be noted that the point of inflection of the growth curve is shifted upward in response to topping and priming. The increase in weight is the result mainly of increase in size of the leaves. That increase in leaf size will result from topping is well known to all tobacco growers and is the prime reason for topping, as commonly practiced with all types of tobacco except certain aromatic kinds. These include Trabzon, Tik-Kulak, and Assor (a Sirdilli kind) varieties, grown in the Black Sea region of the U.S.S.R., and Samsun when grown on the black plains soils of the Kuban and Maikop districts. Materials elaborated in the leaves of topped plants that would have been utilized in the production of flowers, capsules, and seed are employed instead in the enlargement of all leaves not yet full-grown at time of topping. The enlargement of the leaves on topped plants is therefore a compensatory response in which the entire plant reflects physiologic imbalance.

From these observations, showing an upward shift in the point of deflection of the growth curve in response to topping, one may assume that two sets of regulating or harmonizing factors are operative during growth and development. One set of factors, presumably hormonal, regulates or controls vegetativeness. Another set of factors, also hormonal, regulates flowering and fruiting. These two sets of factors are not additive but subtractive or are oppositional. Vegetativeness dominates growth up to the point of deflection of the growth curve. At this point the two sets of factors are in balance, but as growth continues the factors controlling flowering and fruiting become increasingly dominant over the factors that control vegetativeness. In substantiation of such explanation for the sigmoidal shape of the growth curve and for shift in the point of deflection, it may be said that hormonal regulation of growth processes is a well-established fact, even though no one has isolated and chemically characterized the factors governing vegetativeness or those governing flowering and fruiting.

Among the best-known hormonal growth regulators of plants is indole-3-acetic acid. It is of more than passing interest, however, to point out that, as shown by Crosby and Vlitos (1959), "growth of plants may be governed by a more or less complicated system of regulators rather than by a single auxin, such as indole-3-acetic acid." They found that this auxin is absent in Maryland Mammoth tobacco and that growth regulation is promoted by a long-chain fatty alcohol.

Attention may also be directed to the comparative size of leaves on any given plant. There is a progressive increase in leaf size upward to the median stalk region, after which the leaves become progressively

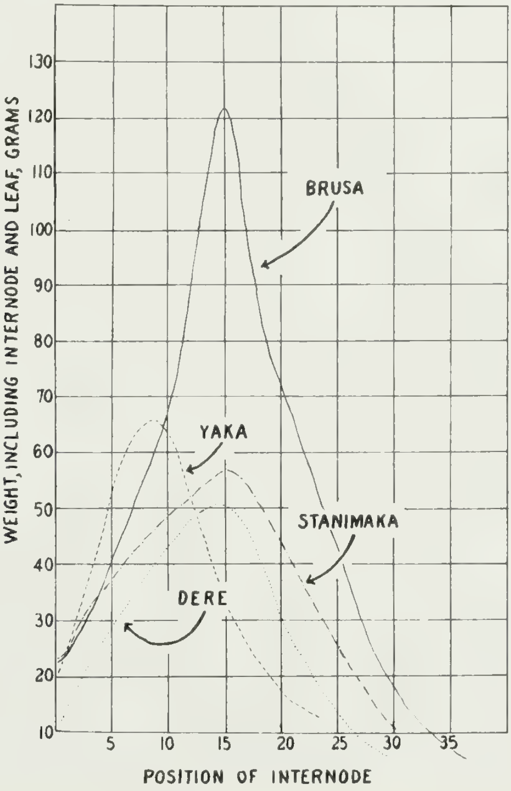

FIG. 31. Growth curves of four varieties of aromatic tobacco in which cumulative weight of successive internodes and leaves is plotted against position of the internode.

smaller. These facts as they relate to leaf size (green weight) and stalk position are shown graphically in Fig. 31, for four rather widely different oriental varieties, Brusa, Dere, Stanimaka, and Yaka. The curves, Fig. 31, have been smoothed to remove irregularities arising from fluctuations in growth rate, attributable to changes in weather. The curve for each variety is seen to resemble a normal distribution or population curve. The differences in leaf weight shown express the characteristic differences in leaf size among these varieties. They also show that the absolute growth rate, called intensity of growth by Berthold (1929), involves to the greatest degree the leaves in the region near the point of deflection of a sigmoidal growth curve. This fact could be portrayed better, perhaps, if the data were presented in a manner to show the relative rate of expansion of the leaves borne at different stalk positions, meaning the percentage of daily increase in leaf size based on final size or size at maturity. Such data for leaves from three regions, lower, median, and upper stalk position, shown in Fig. 32, indicate that the relative rates of expansion are quite alike. At least, the differences from use of field-grown plants are of such magnitude as to be attributable mainly to differences in prevailing weather.

The most significant feature established by studies on the physiology of growth is that, for the production of a vintage crop of aromatic tobacco, the rate of growth throughout the entire period from establishment of the seedlings after transplanting in the field until the end of harvest should be approximately uniform. The growth curve for such a crop, in which the units representing increase in weight of successive internodes combined with the weight of the corresponding leaf are plotted against elapsed time, are shown in Fig. 33. This curve is seen to approximate a straight line, and the more nearly it approaches a straight line the more ideal have been the growth conditions. It is possible to provide for such favorable conditions to a large extent by giving attention to (*a*) the supply of nutrients, (*b*) the variety being grown, and (*c*) the supply of moisture. The mineral nutrients used preferably should be in the form of organic materials, such as manure or other decomposable matter. Such materials would best furnish the growing plants with a continuous supply of nutrients. The results of years of experience from the use of sheep and goat manure as fertilizer by growers of aromatic tobacco in the Near East supports this condition. Commercial fertilizers are too largely inorganic and are too readily available to provide for a uniformly continuing supply of nu-

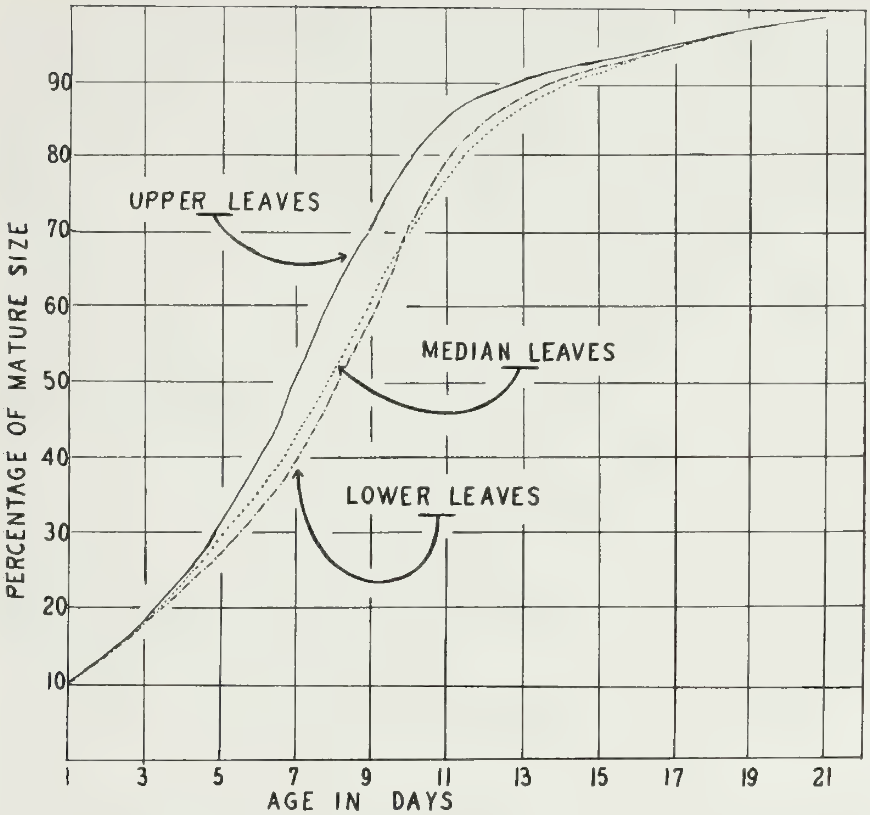

FIG. 32. Comparative rate of growth of leaves from different stalk regions.

trients, hence are materials of second choice as fertilizer for aromatic tobaccos.

As regards varieties, experience has shown that some reach maturity early, that others are late, and that even within a fairly stable variety some of the plants may flower approximately a month later than others. Such late-maturing ones should be isolated by selection, to provide sources of seed, for the reasons that the largest yield, greatest volume of aroma, and best leaf texture tend to be correlated with late maturity.

An adequate supply of soil moisture throughout the entire growing season is a correlated essential factor. Soils of fine texture, such as clays, that have an appreciable quantity of organic matter and humus serve to provide for an adequate supply of soil moisture. In much of the Near East, and in South Africa and Rhodesia, rainfall is scant throughout the growing season. Proximity to the Black Sea and Aegean

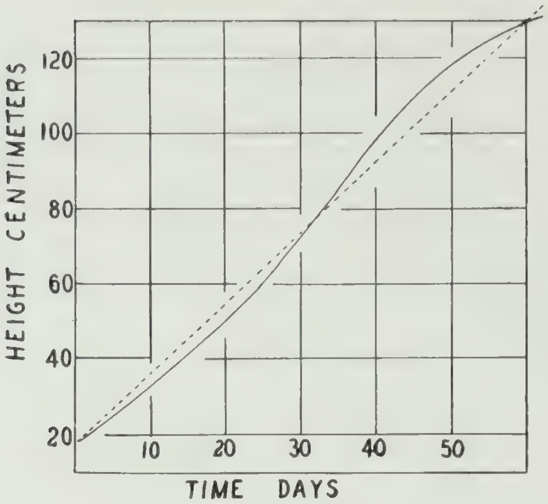

FIG. 33. Sigmoidal growth curve of a vintage crop of aromatic tobacco showing a high degree of uniformity in rate of growth.

Sea partly compensates for lack of rains by providing periods of high relative humidity or else favors the accumulation of dew. In Venezuela, the crop is grown during the dry season, hence must be irrigated.

Physiology and leaf structure

In a subsequent chapter it will be shown that the chemical composition of leaves from different primings is different. To explain such differences one may assume that the leaves of each priming are physiologically different. Correlated with these chemico-physiologic differences are morphologic differences, next to be considered and interpreted. In 1944 Wolf and Jones (1944) measured the average length/width ratio of the leaves of different primings of several varieties

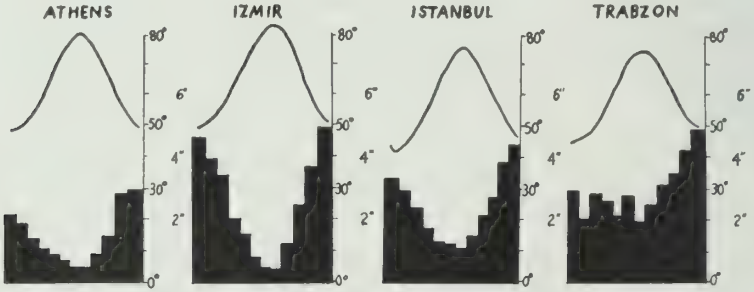

FIG. 34. Average monthly temperature (Fahr.) and rainfall (in inches) at four Near Eastern Stations. The summer months are very hot and dry, except in the vicinity of Trabzon.

TABLE XII. LENGTH/WIDTH RATIO OF LEAVES OF CERTAIN AROMATIC TOBACCO VARIETIES

Variety	*Priming*					
	1st	*2nd*	*3rd*	*4th*	*5th*	*6th*
Brusa	1.41	1.51	1.55	1.66	1.74	1.61
Jenidze	2.44	2.63	2.86	2.87	2.91	2.82
Stanimaka	1.79	1.80	1.83	1.88	1.80	1.78
Xanthi Djebel	1.66	1.51	1.52	1.64	—	—
Ayasolouk	2.12	1.98	2.05	1.99	1.95	1.92

of aromatic tobacco. Results of these measurements of green leaves, using maximum length and maximum width, are presented in Table XII.

These data clearly show that the shape of the leaves borne at different stalk positions is different. It may be assumed that such differences are attributable to physiologic changes induced by priming. The differences are also reflected by shrinkage during curing. Pertinent data on this point are assembled in Table XIII.

These data show that the amount of shrinkage of different primings differ within the range of approximately 32% to 40%.

Physiologic differences among the leaves of different primings are also indicated by differences in thickness of the green leaves. Measurements to show such differences are contained in Table XIV.

TABLE XIII. REDUCTION OF LEAF AREA DURING CURING, EXPRESSED AS PERCENTAGE OF GREEN LEAF AREA

Variety	*Priming*					
	1st	*2nd*	*3rd*	*4th*	*5th*	*6th*
Brusa	64.6	63.5	66.2	64.7	63.0	65.8
Jenidze	64.2	66.9	65.0	62.7	67.9	63.5
Stanimaka	63.2	59.5	62.1	60.3	61.5	61.1
Xanthi Djebel	62.2	64.1	66.2	69.0	—	—
Ayasolouk	62.1	67.6	63.9	60.9	63.7	64.4

TABLE XIV. THICKNESS OF GREEN LEAVES OF CERTAIN AROMATIC TOBACCO *(microns)*

Variety	*Priming*					
	1st	*2nd*	*3rd*	*4th*	*5th*	*6th*
Brusa	305	290	278	254	249	262
Jenidze	297	295	257	247	262	256
Stanimaka	325	262	235	243	218	249
Xanthi Djebel	328	302	286	241	—	—
Ayasolouk	273	260	234	225	234	238

These measurements were obtained by use of calipers designed to determine the thickness of paper. The accuracy of measurements was tested by comparison with transverse sections of leaves that had been embedded in paraffin. By this means it was found that the thickness measurements shown for the small leaves or for those of the last primings are too large. This is due to the closeness of small veins, which made it impossible to measure the interveinal thickness. It is the general opinion among tobacconists that the uppermost leaves are the thickest. As shown, however, they are actually the thinnest. They merely feel thicker because of the small veins and the close-standing glandular hairs. Real difference in thickness of leaves of the different primings is traceable to differences in volume of intercellular spaces and to the degree of expansion of constituent cells of the given leaf, not to the number of cells of which it is composed. Each leaf on a plant of a given variety of aromatic tobacco apparently consists of approximately the same number of cells.

The differences among leaves of different primings in length/width ratio, in shrinkage on curing, and in thickness are believed to be compensatory responses induced by priming. As a result of the removal of hand after hand of leaves, as harvesting proceeds, there remains an increasingly smaller and smaller functional leaf area, and the physiological balance throughout the entire plant becomes increasingly disturbed. The plant continuously reacts in a way to equalize or to bring into equilibrium the stresses in leaf/stem/root created by the removal of the leaves. In so doing both chemical differences and structural differences among primings result. Such responses exemplify the operation in tobacco that is harvested by priming of the physico-chemical principle known as Le Chatelier's law, which states, in effect, that when some stress is brought to bear on a system in equilibrium, and as a consequence the equilibrium is unbalanced, a change on the system occurs in that direction which tends to minimize the effect of the stress. Too frequently in physiological studies the fact is not appreciated that a plant is a united whole. Its parts do not function independently or without relation to each other in response either to external factors or to internal ones. This is to say that its functioning is not the arithmetic summation of that of its parts but instead is that of all of the intricately interdependent metabolic activities.

Such interdependent unity of functioning is succinctly stated by Sinnott (1960, *vide* p. 459), as follows: "It is important to a student

TABLE XV. SIZE AND SHAPE OF LEAVES OF ORIENTAL VARIETIES OF TOBACCO

	Variety	*Condition*	*1st*	*2nd*	*3rd*	*4th*	*5th*	*6th*	*Average*
Average leaf area, cm.^{2}	Brusa	green	167.3	261.9	254.6	187.2	120.9	53.3	174.2
		cured	108.8	166.2	168.7	121.2	76.2	35.1	112.7
	Jenidze	green	138.1	246.7	188.9	141.0	81.3	41.4	139.6
		cured	88.6	165.1	122.7	88.4	55.2	26.3	91.1
	Stanimaka	green	177.0	293.1	266.7	186.1	85.1	39.1	174.5
		cured	111.8	174.3	165.6	112.3	52.3	23.9	106.9
	Djebel	green	88.0	144.3	153.4	90.8	—	—	119.1
		cured	54.7	92.5	95.9	62.1	—	—	76.4
	Ayasolouk	green	240.9	277.4	234.9	129.8	66.9	49.5	166.6
		cured	149.7	187.6	149.9	79.0	42.6	31.9	106.8
Length/width ratio of leaves	Brusa	green	1.41	1.51	1.55	1.66	1.74	1.61	1.58
		cured	1.57	1.71	1.78	1.81	1.76	1.75	1.73
	Jenidze	green	2.44	2.63	2.86	2.87	2.91	2.82	2.75
		cured	3.05	2.98	3.09	3.19	3.20	2.11	2.43
	Stanimaka	green	1.79	1.80	1.83	1.88	1.80	1.78	1.81
		cured	1.98	1.98	1.98	2.15	1.96	1.84	1.98
	Djebel	green	1.66	1.51	1.52	1.64	—	—	1.58
		cured	1.80	1.84	1.75	1.67	—	—	1.76
	Ayasolouk	green	2.12	1.98	2.05	1.99	1.95	1.90	2.00
		cured	2.33	2.22	2.21	2.16	1.95	1.93	2.14
Shrinkage during curing as % of green leaf area	Brusa		64.6	63.5	66.2	64.7	63.0	65.8	
	Jenidze		64.2	66.9	65.0	62.7	67.9	63.5	
	Stanimaka		63.2	59.5	62.1	60.3	61.5	61.1	
	Djebel		62.2	64.1	66.2	69.0	—	—	
	Ayasolouk		62.1	67.6	63.8	60.9	63.7	64.4	

of life sciences to remember . . . that a living thing is an *organism,* that there is an interrelationship among its parts which is manifest in development, and that, if this system is disturbed, it tends by a process of self regulation to restore itself."

Physiology and glandular hairs

It is well known that the "gum" which accumulates on one's hands or clothing from contact with tobacco plants consists of the exudate from glandular hairs that are abundantly present on the stems and leaves. Observations (Wolf and Jones, 1944) have shown that each leaf on a given plant of an oriental variety has approximately the same number of glandular hairs, so that the population density of such hairs per unit of leaf area on the small leaves may be two to five times that of the largest leaves. Characteristic aroma arises mainly from the glandular exudate. Quality of cured leaves and leaf size are known to be correlated. Volume of aroma is therefore correlated directly with leaf size and with population density of glandular hairs per unit of leaf surface.

Chemical studies of the nature of the exudate show that it is a complex mixture of ethereal oils, waxes, and resins. Little is known about the physiology of the formation of this exudate. Elaboration of exudate is a continuing metabolic process, however, as shown by the fact that the leaf surface may be washed quite free of gums by rains. Then after a few hours of hot, bright sunshine such leaves are again very gummy. It is for this reason, therefore, that experienced growers do not harvest immediately after rains.

As shown in Chapter III, the hair glands contain chlorophyll. For this reason carbohydrates may be formed within the glands and must serve as proximate sources from which oil, resins, and waxes are elaborated.

According to Brückner (1936) one can, by means of steam distillation, fractionate the exudate of glandular hairs, finding volatile ethereal oils that will yield ketones, aldehydes, esters, and various kinds of acids. But nothing has been learned about why the aroma of different varieties differs in quality and quantity. Methods for their measurement remains to be improvised. One can assume with some degree of certainty that glandular hairs synthesize constituent materials in differing amounts. Evidence that such is the case rests upon the fact that aroma can be modified by such factors as spacing, kind and amount of mineral nutrients available, amount of rainfall, and duration of sunshine.

Many investigators have noted that hairiness in plants varies in response to intensity of illumination. Only limited observations on the influence of light on hairiness of aromatic tobaccos are available (Wolf, 1946). Leaves of field-grown plants of Ayasolouk and Brusa grown under a cheese-cloth shade tent were compared with leaves grown outside the tent with the results shown in Table XVI.

As may be seen, shading caused the leaf size to be reduced, the total per-leaf hair population to be reduced, and the per-unit area population to be reduced. The shaded leaves were about two-thirds as large as those in full sunlight, their hairs were about three-fifths as numerous, and their density was about 10% less. No doubt such profound changes would be accompanied by changes in aroma.

The effects of availability of mineral nutrients and moisture on quality of aromatic tobaccos is very evident when comparison is made between crops grown on alluvial or colluvial plains (*ova*) and those on the slopes or crests of hills or mountains (*yaka* or *djebel* respectively). When grown under such conditions the *ova* crops are deficient in resins and waxes. The leaves are large, loose textured, and are quite neutral in aroma and flavors, being generally used as filler. Reduction in spacing to between-row intervals of 30 cm. and between-plant intervals of 10 cm. or less tends to equalize the differences between *ova* and *yaka* crops.

The influence of light on quality of aromatic tobacco has never been given the consideration that should be accorded such a study. So far as the writer is aware, no one has been able to produce in a greenhouse leaf of this tobacco that is acceptable commercially. Whether this is due primarily to insufficient exposure to ultraviolet rays, as one might suspect, has not been demonstrated. It may well be that total radiation, including both total hours of sunshine (duration) and light intensity, is all important rather than the effects of radiant energy of any particular wave length. As regards duration, it has been noted in Macedonia, where the best Xanthi tobaccos are grown, that there are from 1486 to 1775 hours of sunshine during the period from transplanting to the end of harvest.

Physiologic function of nicotine

With fairness, it may be stated that nicotine is the most interesting and important constituent of cultivated tobacco. This compound and its related alkaloids in *Nicotiana tabacum* and other species have been the subject of many studies by agronomists, biochemists, chemists, pharmacologists, and physiologists. The limits imposed by the nature of this treatise do not justify a comprehensive review of their many publications. For this reason the present account will be confined to a

TABLE XVI. COMPARISON OF NORMAL ILLUMINATION AND ARTIFICIAL SHADE ON HAIRINESS OF AYASOLOUK AND BRUSA TOBACCO

Variety	*Av. leaf area, cm.^{2}*		*Hairs per leaf, thousands*		*Hairs per cm.^{2}*	
	normal	*shaded*	*normal*	*shaded*	*normal*	*shaded*
Ayasolouk	148.8	130.5	160.6	112.2	115.0	86.0
Brusa	187.9	128.8	235.4	135.3	124.0	105.0

brief enumeration of such findings as bear directly on the occurrence and distribution of nicotine and its probable function in the growing plant. Other aspects of the subject are discussed in Chapter IX.

It has been well established that (1) nicotine is elaborated in the roots of cultivated tobacco and is transferred to the above-ground structures, being most abundant in the leaves, where it is localized in greatest amounts in the tips and margins. (2) Young root tissues contain proportionally more nicotine than is found in old ones, probably for the reason that old roots have a greater proportion of skeletal or woody tissues. (3) If plants are permitted to grow in their natural state their nicotine content tends to occur as a decreasing gradient upward from the basal parts. But if the inflorescence is removed by topping and suckering, the uppermost leaves and the stem tip contain the largest amounts of nicotine. (4) There is much less nicotine in the stalk than in the roots and leaves. (5) Nearly all investigators maintain that tobacco seed contain no nicotine. However, by use of spectrophotometric means it has been demonstrated that the seed of certain aromatic varieties contain traces of this alkaloid. Moreover, investigations made at the Connecticut Agricultural Experiment Station and that at Krasnodar, U.S.S.R., reveal that the seed contain detectable amounts of certain amino acids and related substances including arginine, adenine, betaine, coline, guanine, histidine, and lysine. These materials have been postulated to enter into the metabolism of nicotine, although accord has not been reached on the sequence of events leading to its elaboration. (6) During germination of the seed there is a decrease in reserve protein with a correlated concomitant increase in soluble nitrogen and increase in nicotine. Exposure of the cotyledons to light appears to be an essential factor in these metabolic activities. (7) The quantity of nicotine produced is influenced largely by the availability of nitrogen from materials used in fertilization of the growing crop. (8) Various hypotheses have been suggested to account for the possible use of nicotine made by the tobacco plant. Of these the most plausible one appears to be that it serves as a regulator of acidity in processes involving the metabolism of nitrogen. A measure of support for this hypothesis resides in the fact that the content of such acids as oxalic, citric, and malic, present as salts, is largest in plants having the greatest content of nicotine. Moreover, there is a continuous decrease in amount of nicotine in tobacco leaf tissues during curing and fermentation, with accompanying formation of acids.

Seed germination

Mature seed of aromatic varieties of tobacco are immediately capable of being germinated. The requirements for germination are moisture, favorable temperature, and light. There is disagreement on whether light is required. Certain varieties are said to germinate when kept in absolute darkness. Temperatures within the range 30° to 35° C. are optimal for germination for most varieties. Muraoka (1952) found that seed of some of the varieties of tobacco grown in Japan germinate best in light at low temperatures and others in darkness at high temperatures, indicating the existence of correlation between light and temperature.

Seed are capable of germination even after long periods of storage. If kept in the laboratory under widely varying conditions of temperature and relative humidity, germination is feeble in ten-year-old seed, but three- to four-year-old seed germinate well. Poptzoff (1933) made extensive studies of storage conditions for tobacco seed and recommended placing the seed in containers that are not airtight and that are maintained at 30° to 60° F. and at low relative humidity. When placed over calcium chloride to maintain a low relative humidity seed have been found to be viable after storage for thirty years.

Tobacco seed contain 6% to 8% moisture, 37% to 45% oil or fats, and 23% to 28% protein. They are starch-free. It is generally maintained that tobacco seed are nicotine-free, but evidence exists that trace amounts of alkaloids are present in the seed of certain varieties. The oil is semi-drying and consists of 60% linoleic acid, 25% oleic acid, with small percentages of stearic and palmitic acids.

Steinberg (1960) stored seed of 57 species of Nicotiana at 50°F, placing them in tightly stoppered glass vials and in manila seed-envelopes. He found, for each species, that viability increased for at least three to four years, and suggested that seed stocks may be maintained by propagation at about five-year intervals.

Ecologic considerations

Aromatic tobaccos are well known to be the product of two combined, interdependent factors, climate and soil, whose separate effects are difficult to evaluate. Since the many other kinds of tobacco grown throughout the world differ so markedly from each other, it appears reasonable to assume that the characteristic differences among them are also traceable primarily to climate and soil. But ecologic data to support this conclusion for any given type of tobacco based on the correlated effects of meteorologic and edaphic factors are meager. It appears that the most extensive, pertinent study of this kind relevant to aromatic tobacco is that of Georgievski (1957), made in the environs of Prilep, Yugoslavia. His findings have wide application throughout the entire Macedonian region. They show that infertile soils which provide minimal amounts of moisture during the growing season determine the size of leaves, their texture, aroma, nicotine content, combustibility, etc., features that characterize aromatic tobaccos of superior quality.

Certainly further studies of evapo-transpiration and of the exact regional amount of water that this crop requires would prove to be very useful and very profitable. Aromatic tobacco plants are not xerophytic in structure, yet they grow in soils of very limited water-holding capacity and in very dry climates. Small amounts of moisture, as from dews that may occur frequently, are exceedingly important. Balcar (1958) studied the influence of the accumulation of dew on tobacco in Czechoslovakia. He reported that 0.1 mm. of dew deposited on the leaves of 40,000 plants per hectare is equivalent to 4,000 liters of water, and that 0.15 mm. was an amount sufficient to keep the leaves fresh for eighteen hours during the twenty-four hour period, whereas plants without dew remained fresh for thirteen hours only during a like period. Moreover dew may be deposited nearly every night in many parts of the Near East. These findings emphasize the fact that dew is a very important factor in regions where paucity of rainfall and high temperature prevail. Thus the frequency of dews and the amount of water accumulated on aromatic tobacco plants exerts a profound influence in determining the size of leaves, and, in this manner, the grade and quality of the crop.

Summary

The physiology of aromatic tobacco is considered from the point of view of plant growth. Growth is interpreted not as increase in size but as the interaction of all interdependent metabolic processes. Size increase may or may not result from these metabolic processes. Growth may be expressed by a growth curve which shows that rate of growth changes with age. The fact that the sigmoidal growth curve of a vintage crop of aromatic tobacco closely approximates a straight line indicates a continuously uniform metabolic rate.

Physiologic imbalance in root-stem-leaf ratio, induced by priming, is used to account for the structural and chemical differences among the leaves of different primings. Aroma appears to be traceable primarily to the exudate elaborated by the glandular hairs.

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Chapter Five

QUALITY IN AROMATIC TOBACCO

Quality in tobacco is a subtle feature that is difficult to define but refers to properties possessed by the leaf that make it desirable for specific purposes. As is well known, different types of tobacco have different properties or quality elements. As regards aromatic tobaccos these desirable elements are related principally to aroma, flavor, and combustibility. Fortunately in aromatic tobaccos each of these elements is compatible with each of the others. Each of them, in turn, is a complex, consisting of factors that are not completely understood. They express themselves in response to the many features that make up the soil environment, the prevailing weather during the growth of the crop, the special cultural and handling practices accorded the plant and its product, and lastly the genetic constitution of the plant itself.

Judgment and measurement of quality in tobacco is made in a different way by each of three groups of persons: (1) buyers and manufacturers, (2) chemists, and (3) smokers. Each group employs different criteria, but there is a remarkably close correlation in their judgment and findings. Those of the first group have learned from years of experience to associate superior, good, medium, fair, and poor quality of a given type of tobacco with leaf size, color, texture, aroma, etc., as evaluated by appearance, feel, and smell. Those of the second group have learned to associate amount and proportions of organic and inorganic constituents with different grade groupings. But in the final analysis, quality in aromatic tobacco is determined by the smoker himself. He must find the aroma to be pleasurable, the taste agreeable and flavorful, and the physiological affects satisfying. Few smokers find that any given kind of aromatic tobacco by itself or even any given priming of any given variety possesses all of the features of which quality is composed. In certain varieties, for example in Samsun, all requirements of quality are somewhat approximated if a mixture is made of different hands blended in the same proportion as that in which they are produced. But for nearly all persons quality is best expressed as a result of blending different varieties of oriental tobacco or else blending oriental tobaccos with tobaccos of other types, employing such kinds and amounts of oriental tobacco as will produce the desired aroma, flavor, and combustibility. The addition of the desired kind and amount of aromatic tobacco to make a blend to please the smoker is quite analogous to the practice of adding condiments, spices, and extractives to make foods more appetizing.

The tobacconist has learned by experience to evaluate quality among aromatic tobaccos as being correlated with certain physical properties that he determines, in the following order, by the senses of touch, sight, and smell. In addition, chemical properties, or chemical constituents have been found to be correlated to a remarkable degree with physical properties. In the brief account that follows both groups of properties will be considered.

Physical properties

Leaf size and shape—Leaf size is all important among the physical properties of aromatic tobaccos. This conclusion is substantiated by the existence of aromatic and semiaromatic kinds, both grown from the same kind of seed, but under different soil and climatic conditions or with different spacing intervals. Those tobaccos of large leaf size are semi-aromatic. It is also supported by the differences among leaves borne at different heights on the stalk, the upper leaves always being smallest and of superior quality. Leaf size is completely independent of leaf shape, however. The numerous varieties of aromatic tobacco have many shapes, types of leaf bases and of attachment to the stalk, and also kinds of leaf tips.

The differences among varieties of aromatic tobacco in leaf size, shown in Table XV, are very apparent, some being two to three times as large as those of others. During curing leaf size is decreased, cured leaves being approximately 60% to 65% as large as green leaves. Decrease in size and change in shape upward on the stalk are gradual and consistent within each variety. Change in shape is a response to disturbance of balance in growth, consequent on priming. There occurs also a change in shape with shrinkage during curing which may be presumed to arise because of the amount and arrangement of the ribs or framework (skeletal tissues) of the leaf.

Leaf thickness and density—Thickness of the leaf may be measured with a fair degree of accuracy by use of calipers, but it is usually determined by the impression gained from the sense of touch. From such an impression one gains a knowledge also of leaf density, that is, the compactness and size of leaf cells as related to the volume of intercellular spaces. The leaf is said to be loose textured or close textured, depending upon its density.

One may gain the impression from handling the green leaf that the upper leaves are thicker than the lower leaves or those from the middle stalk position, whereas they have been shown by microscopic examination to be thinner. The numerous small veins and the dense coating of hairs at the leaf surface are responsible for this erroneous impression of thickness, as judged by the sense of touch. All leaves on a plant of a given variety tend to have the same number of constituent cells, but the cells of the upper leaves expand to a lesser degree, hence the upper leaves are actually thinner. This fact is shown by measurements assembled in Table XVII.

The data in Table XVII, obtained by measurements with calipers, show a progressive decrease in leaf thickness with successive primings upward on the stalk, except in the sixth primings (Wolf & Jones, 1944). Microscopic examination of cross sections of the leaves showed that these measurements were in excess of the actual thickness because of the network of fine veins that made it impossible, by use of calipers, to measure correctly the thickness of the interveinal tissues.

Various attempts have been made to measure "apparent density" as related to body of the leaf. Among such studies is that of Darkis, Pedersen, and Gross (1941). Their findings show that light-bodied, flue-cured tobaccos are low in nitrogenous materials and sugars and

TABLE XVII. THICKNESS OF GREEN LEAVES OF SEVERAL VARIETIES OF AROMATIC TOBACCO AS RELATED TO STALK POSITION *(microns)*

Variety	*Priming*					
	1st	*2nd*	*3rd*	*4th*	*5th*	*6th*
Brusa	305	290	278	254	249	262
Jenidze	297	295	257	247	226	256
Stanimaka	325	272	235	243	218	249
Djebel	328	302	286	241	—	—
Ayasolouk	273	260	234	225	234	238

high in acid and ash content, whereas good-bodied leaf is high in nitrogenous materials and sugar and low in acids and ash. As regards density of Turkish tobacco, Türkdogan (1939) subjected a given volume of pulverized leaf to a definite pressure and calculated the density from the readings obtained. He concluded that density is directly correlated with the percentages of chemical constituents.

In general, leaf thickness and density are related to body, a term that includes specific weight. Leaves that are very thin and chaffy are deficient in body and for this reason are undesirable.

Elasticity—Aromatic leaf of good quality, when sufficiently moist to be in order, will undergo stretching without tearing. Such tobacco, after being compressed, as occurs during cutting in the manufacture of cigarettes, will expand immediately; this expansion gives it filling power.

Waxes, resins, and ethereal oils—With aromatic tobaccos the sticky, gummy secretions of the glandular leaf hairs are of primary importance. These exudations consist of ethereal oils, resins, and waxes. They increase in amount as the leaf matures, especially if the gums are not removed by rains. They undergo polymerizations and other transformations during aging and fermentation, producing products that are essential sources of the characteristic aroma and flavor. The presence of these materials makes the leaves of baled tobacco stick together and causes the crackling sound, as of paper being torn, when bales are opened for inspection. Volume of aroma, but not necessarily quality, is conditioned by the amount of gummy, resinous materials on the aged and fermented leaf. When the aromatic tobacco is being smoked, these materials undergo distillation in the burning zone, the gases evolved by tobaccos of good quality being appreciated for their characteristic pleasant smell and taste.

Different varieties of tobacco, as is well known, possess different aroma characteristics, a matter to which special consideration was given by Kosmodem'ianskii (1956). It seems highly probable that constituent carbonyl compounds in different proportions together with volatile esters and organic acids will eventually be shown to account for these differences in aroma.

Color—Color in itself is of little importance as regards the quality of aromatic tobaccos. Its use in judging quality, however, is enormously important because color is correlated with other characteristics. Among these tobaccos there is a wide variety of colors, including lemon-yellow, orange, orange-brown, greenish-yellow, light-brown, reddish-brown, yellowish-brown, brownish-yellow, and variously mottled colors. Dull greenish leaf and dark lusterless brown leaf are highly undesirable. Regardless of the kind and depth of color, it is of great importance that the leaf should possess luster and brilliance.

The color of the leaf depends upon many factors such as variety, soil type, maturity of the leaf when harvested, kind and amount of nutrients available to the growing crop, curing conditions, and aging and fermentation conditions. Experience has shown that, knowing the variety and the region where the crop was grown, one can fairly accurately judge the quality of aromatic tobaccos by the color of the leaf. Some tobacconists maintain that color is conditioned by exposure to sunshine and to variable moderate to high temperatures. However, leaves having lustrous lemon-yellow and light-brown colors have been secured when the entire curing process took place without exposure of the leaves to sunshine.

Hygroscopic properties—The moisture-absorbing and moisture-retaining property of tobacco varies with the type and grade. When tobacco contains sufficient moisture to permit handling without breakage it is said to be "in order." Among the chemical constituents that control hygroscopicity are gummy resinous materials extractable in petroleum ether. Such materials constitute a large proportion of the petroleum ether extractive, that is, measured by routine chemical analyses.

Other organic materials, especially sugars, influence the moisture-absorbing properties. Among the elemental constituents, chlorine exerts the most pronounced effect, tending to make the leaf limp and soggy. Combustibility, as anticipated, is markedly modified by moisture content, the most desirable smoke being produced at moderate content of moisture.

Chemical properties and combustibility

Combustibility, or the burning qualities of tobaccos, involves both their physical and chemical properties. This characteristic has been studied extensively from several points of view, including fire-holding capacity, rate of burn, and character of the residual ash. By fire-holding capacity is meant the continuation of glow without flaming. If the tobaccos have good fire-holding capacity, the burning zone of the cigarette will advance uniformly and slowly and the residual ash will be white and will cohere. If the capacity to hold fire is poor, the burning zone will advance unevenly and the ash will be dark and will tend to fall apart. Among others, Wenusch (1937) studied the combustibility of cigar and cigarette tobaccos, those of the latter group including the aromatic varieties Gümüldjina, Nigrita, Brusa, Tachova, and Djebel Basma. He found that conditions enhancing access of air favored fire-holding capacity. Further, the ash content of the aromatic varieties, which ranged from approximately 10% to 16%, was lower than that of flue-cured and cigar tobaccos, and they did not continue to glow as well as did the flue-cured and cigar tobaccos. The ash of the aromatic kinds was alkaline, whereas that of the others was acidic.

Potassium appears to be the ash constituent that favors continuation of glow, whereas calcium and magnesium control the completion of the burning process to make white ash. Chlorine is acidic and definitely retards burning. If present in sufficient amount, it completely inhibits burning. Among other ash constituents that inhibit combustion are sulphur, phosphorus, and silicon.

The density of the leaf structure, that is, its porosity or specific weight, is related to the supply of air available to support the combustion, especially of the cellulose of which the leaf tissues are largely composed. Such organic acids as citric and malic, present as salts of potassium and calcium, favor fire-holding capacity. The sugars present probably tend to retard burning.

As shown in Chapter IX, aromatic tobaccos are low in nicotine, a characteristic correlated directly with high quality. It is well known that the strength of tobacco is dependent primarily upon its nicotine content. Thassitis (1954) states that the nicotine content of 77% of Greek tobaccos ranges between 0.2%–1.2%, about half containing less than 0.5%. Smokers therefore regard aromatic tobaccos as mild. Their smoke lacks harsh and irritating properties and, when blended, imparts a pleasing aroma and taste.

Other nitrogenous constituents should also be low in aromatic tobacco of good quality.

Chemical composition and taste—The investigations of Shmuk (Salzman, 1958) deal with the smokers' evaluation of taste quality. Certain of his relevant data from analysis of Russian aromatic varieties are assembled in Table XVIII. Even though certain data are lacking, the differences in components are consistent among the grades. Shmuk interprets these differences in terms of taste quality in the following manner. He finds that carbohydrates, resins, and ethereal oils influence favorably the quality of the smoke, whereas albumins (water-soluble, simple proteins), pectins, and organic acids exert an unfavorable influence. He points out, however, that taste may not be improved by addition of carbohydrates since by so doing one may disturb the mutual harmony with other components. Similarly a lowering of the albumin content may not improve the taste if it goes beyond a certain minimum limit. Such minimal amount is essential to pleasing aroma, but pure albumin, when burned, produces vile odors.

The results of other analyses show that alkalinity of tobacco smoke appears to be an important criterion to measure taste quality. As the quality of the tobacco increases the alkalinity of the smoke decreases,

TABLE XVIII. CHEMICAL COMPONENTS THAT MODIFY TASTE QUALITY OF SMOKE OF RUSSIAN TOBACCOS

Variety	*Grade*	*Nicotine*	*Free nicotine*	*Ethereal oils*	*Carbohydrates*	*Albumins*
Kuban	I	1.00	0.04	0.30	—	8.08
	II	1.19	0.05	0.22	—	9.63
	III	1.38	0.06	0.16	7.25	9.25
	IV	1.77	0.09	0.16	5.05	10.94
	Poor	1.65	0.08	0.14	2.61	12.94
Dubek	I	—	—	—	—	—
	II	1.23	0.02	0.60	12.85	8.63
	III	1.41	0.05	0.45	12.65	8.94
	IV	1.62	0.06	0.27	9.78	10.63
	Poor	—	—	0.26	6.83	11.00
Samsun	I	0.93	0.01	—	12.39	7.68
	II	1.09	0.02	—	11.65	8.73
	III	1.82	0.03	—	6.18	11.68
	IV	—	—	—	—	—
	Poor	—	—	—	—	—
Maikop	I	—	—	0.34	—	—
	II	—	—	0.25	9.95	9.87
	III	—	—	0.16	6.84	9.51
	IV	—	—	0.15	5.03	12.16
	Poor	—	—	0.13	3.36	12.72

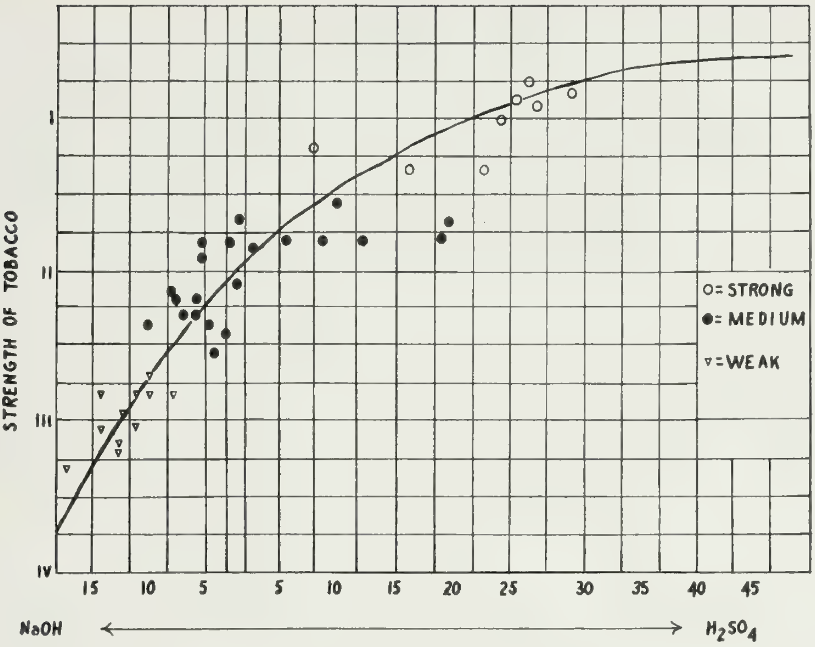

FIG. 35. Relation between strength of taste of tobacco smoke and its alkalinity. Data from Shmuk (1953) arranged by Salzman (1958).

or, in other words, the less alkaline the smoke, the better the quality of the tobacco.

It is well appreciated that the nicotine content of tobacco conditions its physiologic strength response in the smoker, and unless tobacco contains a definite amount of nicotine it does not satisfy the smoker's taste.

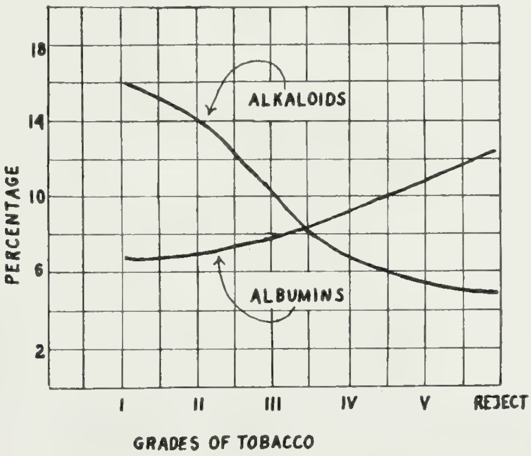

FIG. 36. Correlation of grades of tobacco with percentage composition of alkaloids and albumins. Data from Shmuk (1953) arranged by Salzman, 1958.

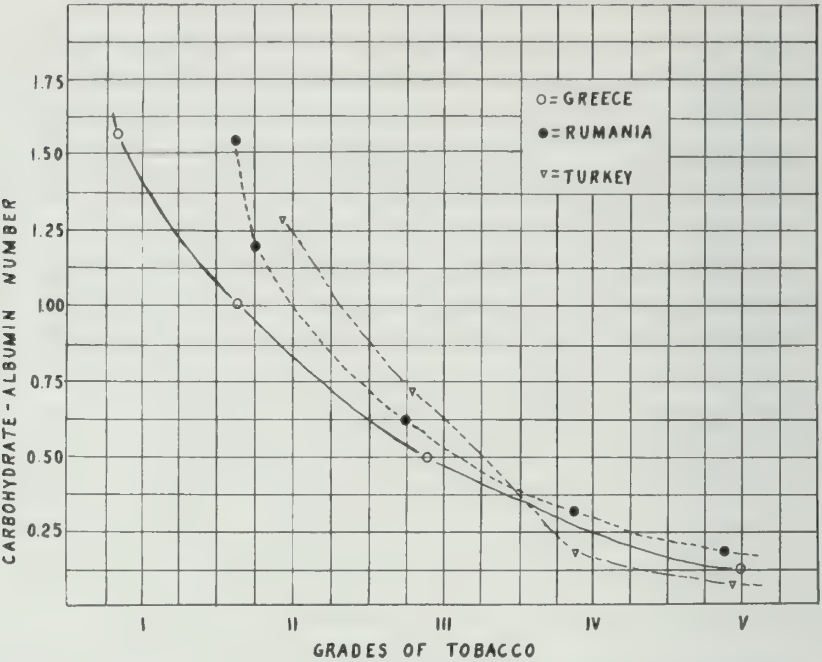

FIG. 37. Quality of grades of tobacco from Near Eastern countries as shown by relationship between content of carbohydrates: albumins, expressed as Shmuk values. Data arranged by Salzman, 1958.

In general, as the quality of the tobacco increases the "free" nicotine content decreases. By "free" nicotine Shmuk means the nicotine that is extractable by steam distillation, or that fraction which occurs in the leaf not in the form of salts. In very strong tobaccos as much as 30% of the total nicotine content may be "free" nicotine.

As regards the role of ethereal oils and tars in the aroma of smoke, Shmuk (Salzman, 1958) established that even when these constituents were removed from the tobacco by means of organic solvents, there still remained traces of tobacco aromas when such tobacco was smoked. From this he concluded that the aromatic properties do not depend alone on ethereal oils and tars.

Taste quality is found to be directly correlated with carbohydrate/albumin ratio, just as it is known to be in the tobacco itself. Tobaccos of superior or good quality usually have a high carbohydrate content and a low content of albumins, as will be indicated in Chapter IX.

Finally, the composition of the smoke and its taste are altered drastically, especially as regards content of nicotine, tars, and alkalinity, dependent upon the rate of combustion.

Summary

Quality in aromatic tobaccos is correlated with certain physical and chemical properties. These include leaf size, leaf thickness, density of structure, elasticity, hygroscopicity, amount and quality of waxes and resins, color, combustibility, ash constituents, and amount and kind of content of nicotine, sugars, and proteinaceous materials. No single variety by itself possesses all of the features included in good quality. For this reason blends of different varieties grown in different regions are always employed in cigarette manufacture. Quality is evaluated in different ways, by buyers and manufacturers, by chemists, and by smokers. Their evaluations are correlated to a remarkable degree.

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Chapter Six

CLASSIFICATION AND GRADING OF AROMATIC TOBACCOS

Introduction

The classification and grading of aromatic tobaccos present many confusing problems because there is little accord as to the bases of groupings. Each country or region has its own bases partly from the reason that the cured tobaccos themselves are appreciably different. These differences are primarily traceable to varietal differences coupled with differences in soil and climate among the regions where the crops were grown. Moreover, the differences among languages necessarily require the use of different terms even though the different words apply to similar or even the same kinds of tobacco.

The position on the stalk at which the leaf was borne is everywhere taken into consideration in grading the cured tobaccos, for the reason that stalk position and quality are widely appreciated to be directly correlated. Custom and market preference together with quality of the tobacco govern the manner in which the leaves are arranged in packaging them preparatory to storage and to sale in world markets. These interrelated matters will be considered in separating aromatic tobaccos into different categories. Even though the categories now in use lack simplicity and uniformity they are quite serviceable and are well understood in the trade. Whether they should be superseded by standardized grades remains problematic.

Major groups—Aromatic tobaccos are generally divided into four major groups: Xanthi, Kavala, Smyrna or Izmir, and Samsun. Even though each of these group names is the name of an important city that is a production center, the names are not to be understood as merely indicating geographical regions. Rather they are arbitrary terms and within each group are included many named varieties. These varietal names are derived by custom and tradition from towns or villages located in regions where the particular kind or variety of tobacco has been grown for a period of years. Each kind is known to connoisseurs to possess traits or characteristics that distinguish it from all other kinds. The seed for several kinds may have the same source, yet there exist subtle differences in the cured leaf in texture, color, kind and volume of aroma, combustibility, flavor, nicotine content, specific weight, ash content, hygroscopicity, and content of nitrogenous and carbohydrate substances. Why the tobaccos should differ is not understood beyond the fact that the differences are correlated with edaphic and climatic factors such as soil type, elevation, slope, exposure, soil content of organic matter, availability of minerals, distribution of rainfall, soil moisture supply, prevailing winds, relative humidity of the air, deposition of dews, etc.

Within each of these four groups the tobaccos are generally divided into three groups, based on altitude of the fields, namely: *ova,* or plains tobacco; *yaka,* or those grown on the slopes of hills and mountains; and *djebel,* or those grown in fields that are at high elevations. The fundamental differences in the soils at these three sites are depth of soil and correlated soil fertility together with availability of water. Spacing between rows and plants, with consequent plant population difference per hectare may be employed to produce crops on these three sites that have approximately similar quality.

Regional groups—One of the most serviceable, broad groupings that may be made in classifying aromatic tobaccos is to separate them into regional categories. If this is done, as Nesteroff (1928) suggests, there are the following groups:

1. Xanthi tobaccos
2. Macedonia tobaccos
3. South-Bulgarian tobaccos
4. North-Bulgarian tobaccos
5. Old Greece tobaccos
6. Smyrna tobaccos
7. Aegean Isles tobaccos
8. Samsun-Bafra tobaccos
9. Trabzon tobaccos
10. Anatolian tobaccos
11. Russian oriental tobaccos
12. Oriental tobaccos from other countries

Leaf groups of cured leaves—In any scheme of classification of aromatic tobaccos, it appears that stalk position provides a basis of primary importance. In Turkey, three major grade groups are employed, *dip* (lower), *ana* (mother) and *ütch* or *uç* (upper). Beginning with the lowermost group or hand that may be discarded, the designations are *dip alti, dip üstü, protomana, defteromana, tritomana, kovalama, ütch alti,* and *ütch üstü.* The *ütch* group is highest in quality, and leaf of second and third quality is produced mainly by the *kovalama* or intermediate group and the *ana* group, but, during sorting, the best *dip* and poorest *ütch* may also be included in the *ana* group.

In Bulgaria the hands produced near the base of the stalk and extending to the uppermost ones in ascending order are: *dip orta* (lower middle), *biuk-ana* (grandmother), *ikindji ana* (second mother), *uekindji-ana* (third mother), *kovalama* (intermediate), utsch-alti (lower tips), and *utsch uestu* (upper tips).

In Rumania the lower leaves are given the name *poală,* those from the midregion of the stalk, *mijloc* 1, 2, or 3, in ascending order, and the top leaves are called *vârf.*

In Greece the growers generally use the same names for the hands as do the Turks. The lowermost leaves, known as *patofila,* are usually discarded. Then in ascending order come first hand, also called *dip,* second hand or *dip alti,* third hand or *bel,* fourth hand or *kovalama bel,* fifth hand or *doruk alti,* and sixth hand or *doruk.* At times the term *dipia* is used for the first hand. Alternatively in ascending order the Greeks use the names *protomana, dhefteromana, tritomana, kuvalama, outch-alti,* and *outch.* In Serbia, the uppermost grade is *avichak,* followed in descending order by *podovrechak, ana, nadpodbir,* and *podbir.*

Buyers of aromatic tobacco grown in the United States recognize seven distinct grades among the four grades, shown in Fig. 38, that are based upon leaf position. These are designated grades D, E, F, G, R, K, and KK. Leaves of premium quality or uppermost leaves are placed in grade D. Next lower is grade E which includes leaves having excellent quality that are borne near the top of the plant. Grade F includes mainly leaves from the middle portion of the plant and also very good leaves from the upper portion that are not of sufficient quality to be placed in grades D and E. In grade G are included good leaves that may be produced on any part of the plant and also leaves of fair

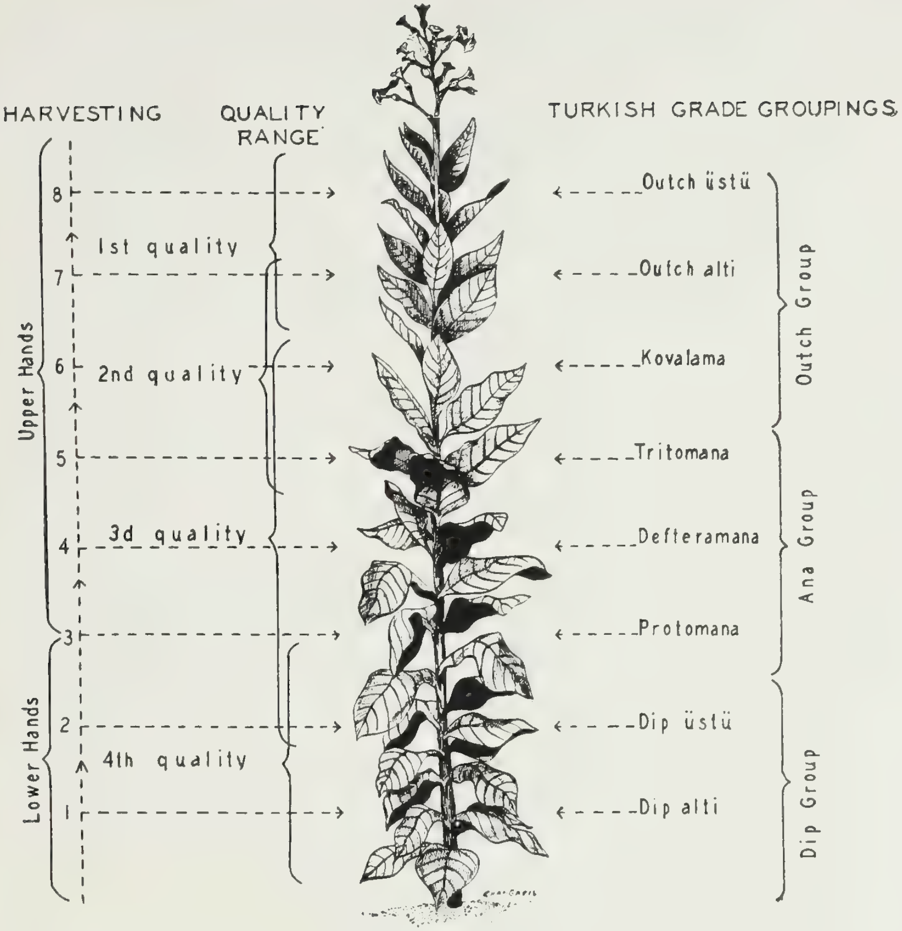


FIG. 38. Classification of aromatic tobacco as related to position on the stalk at which the leaves were formed.

quality from near the top. Grade R contains fair leaves from the mid-region and lower leaves together with poor leaves from the upper portion of the plant. Fair to poor leaf comprises grade K. It may have 50% or less of leaf that has been discarded because of defects due to curing or because of moldiness. Grade KK may not be purchased because it contains more than 50% of discarded leaf.

Since the prices paid to growers by purchasers of the major grades or groups differ so widely it is important to know what proportion of the crop normally belongs in each group. Shmuk (Salzman, 1958) reported the approximate average yield of varieties grown in the U.S.S.R. in grade percentages as follows in Table XIX.

TABLE XIX. PERCENTAGE OF GRADES OF AROMATIC TOBACCOS GROWN IN U.S.S.R.

Grades	Regions				
	Crimea	Kuban	Maikop	Trabzon Sotchi	Samsun Sukhum
I—superior	5	2	5	5	3
II—good	5	5	10	20	5
III—average/medium	20	20	20	40	35
IV—below average	45	45	50	25	37
IVU—poor	25	28	15	10	20

It will be noted that only approximately one-third to one-half of the total production is of a quality that permits the leaf to be classified in Grades I, II, and III, those that normally enter the export markets. Comparable data from other regions are meager but it is probable that they would be similar to those given in Table XIX.

Important varieties—The oriental tobaccos may be divided, for convenience, into several regional groups. Within each such group the cured leaf may be quite distinct even though the source of seed is the same, as previously stated.

Several clearly defined varieties comprise each group. On this basis the following list indicates the principal groups of oriental tobacco and the most important varieties within each regional group, as recorded by Nesteroff (1928). Recent studies, as will be indicated, employ other varietal names in some cases.

1. Xanthi tobaccos
    - Xanthi-Yaka
    - Djebel
    - Souyalissi
    - Gümüldjina (Komotini)
    - Kotchouk-Yaka
    - Xanthi-Karchi-Yaka
    - Sovan-Yaka
    - Jenidze
2. Macedonian tobaccos
    - Zichna
    - Mahala (Machala)
    - Kir
    - Katerini
    - Serres
    - Nevrokop
    - Djumaja
    - Doupnitza
    - Pravista
    - Prosceçn (Prosotsani)
    - Nigrita
    - Salonika
    - Melnik
    - Stroumitza
    - Prilep
3. Southern Bulgarian tobaccos
    - Philipopple
    - Stanimaka
    - Khaskovo-Balkan Ortaköy
    - Kotochoukavak Perustitza
    - Ustina
    - Khaskovo-Ova

4. Thessalian or Western Greek tobaccos
    - Almyros
    - Volos
    - Agrinion
    - Dzembelia (Tsembelia)
    - Myrodata
    - Argos

5. Smyrna tobaccos
    - Smyrna
    - Akhisar
    - Ayasolouk
    - Ghiavourköy
    - Bergama
    - Lighda

6. Aegean Islands tobaccos
    - Samos
    - Chios
    - Mytlin
    - Lemnos
    - Skyros
    - Naxos

7. Samsun tobaccos
    - Samsun
    - Bafra
    - Maden
    - Dere
    - Trabzon
    - Djanik (Çanik)
    - Tach-Ova

8. Anatolian tobaccos
    - Düsdje (Duzçe)
    - Hendek
    - Ismit
    - Gönen
    - Brusa

9. Russian tobaccos
    - Suchum (Sukhum)
    - Kuban
    - Maikop
    - Yalta (Djubek)
    - Assor
    - Tik-Kulak
    - Trabzon

Xanthi tobaccos

The Xanthi tobaccos are universally conceded to be the world's finest aromatic tobaccos, the best of which are collectively known as Basma (derived from the Turkish word *basmak,* meaning pressed). The leaves of Basma when baled in classical fashion are arranged in *pastals* (hands) and layered in series in the bale.

According to Thassitis (1954, 1960) Basma includes the following varieties and grades: Yaka I, Yaka II, Souyalissi, Sovan Yaka, Djebel, Komotini (Karchi-Yaka), Chryssoupoulis (Yaka I, Yaka II, Djebel I, Djebel II, Mahala Drama [Mahala, Mahaladikia]), Kir, Serres, Nigrita, and Pravi or Pravista. Nesteroff (1928) lists nearly all of these Basma varieties, but, in addition, includes Kotchouk-Yaka (little Yaka), and his Gümüldjina-Yaka is identical with Komotini.

Other Greek varieties

Besides Basma, Thassitis (1954, 1960) states that the other varieties grown in Greece include Zichna, Bachi-Bagli, Kaba-Koulak, Smyrna, Samsun, Myrodata, Agrinion Tsembelia, Sari, Mavra, and Argos. A recent map, Fig. 39, shows where these Greek tobaccos are presently being grown, and the tonnage production of each variety. Basma, Bachi-Bagli, and Kaba Koulak are being grown in Macedonia; Samsun or Katerini in the environs of Katerini; Mavra and Sari in the environs of Larissa, Trikala, and Karditza; Agrinion Tsembelia and Agrinion Myrodata in the western part of Old Greece; and Argos in Peloponnesus. Zichna is a narrow-leaf variant, and such narrow-leafed kinds are known as *sirdilli,* (siir-dili) a Turkish word meaning ox-tongue. It is grown in eastern Macedonia and western Thrace. This variety has distinctive aromatic qualities that can be recognized in any cigarette in which it is blended.

Bachi-Bagli includes the varieties Prosotsani (Proseçan), Trabzon (Trebizonde), and Etoloakarnania. Kabak-Koulak from eastern, central, and western Macedonia is intermediate between Basma and Bachi-Bagli and is usually packed as *armathas* (strings of tobacco) in bachi-bagli pastal bales. Katerini, originating from seed from Samsun and introduced by growers who were compelled to leave Samsun, Turkey, centers around Katerini. It is an exceptionally light, readily combustible, light-golden tobacco of delicate aroma. Smyrna or Izmir includes the Aegean Isles tobaccos. This variety is also grown in the Attica area, near Thessaloniki (Salonika), and also in western Macedonia. These tobaccos, when cured, may have a greenish tinge but the ground color is bright yellow. In the region near Karditza a special Smyrna known as Myrodata Paleocastron is being grown; it seems to be intermediate between Basma and Smyrna. Myrodata (aromatic) grown in the environs of Agrinion is said to be a special strain of Bachi-Bagli introduced from Macedonia. The bright golden yellow color of its leaf, mild taste, low nicotine content, and lack of distinctive aroma are its features. Agrinion Tsembelia of western Greece is not at all like Djebel Basma of eastern Macedonia and Thrace but is presumed to be a strain of this variety. It is a rather neutral tobacco but finds favor in the export markets. Sari, because of its brilliant yellow color and excellent filling properties, is favored by cigarette manufacturers in

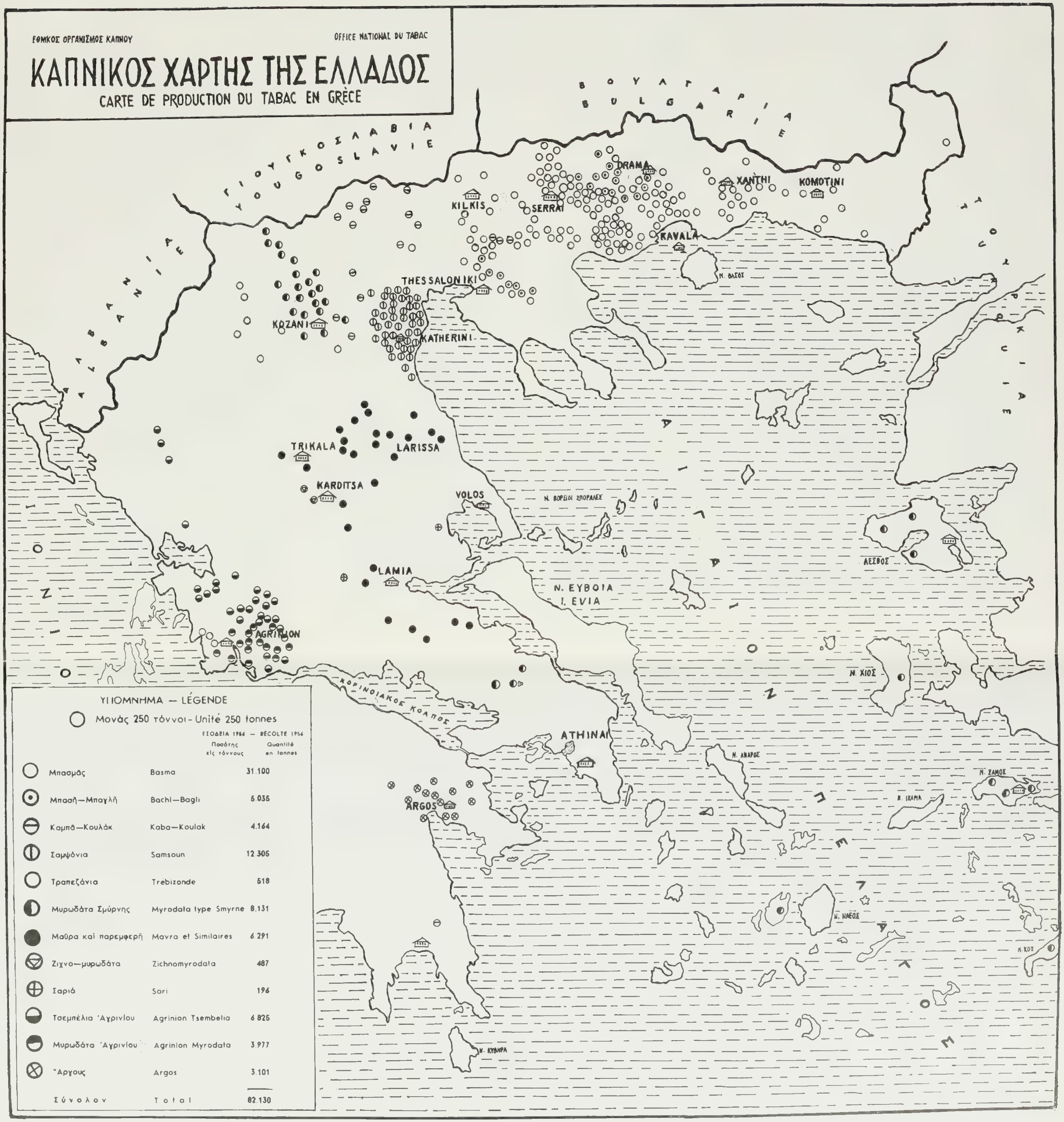


FIG. 39. Map of Greece (adapted) showing the areas in which each of the different varieties is being grown. Each symbol represents 250 tons of merchantable tobacco. The Trebisonde (Trabzon) area is not shown. Subsequent annual production is approximately the same as that shown for the year 1956.

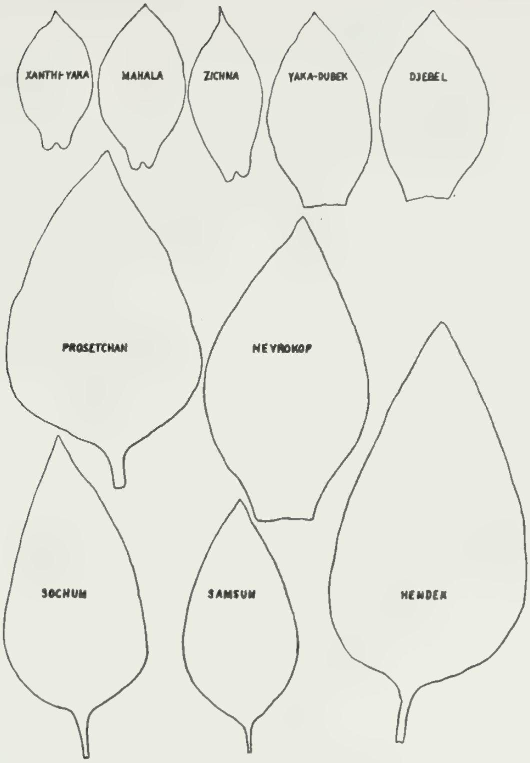


FIG. 40. Comparative average size and shape of leaves of aromatic varieties of tobacco.

Egypt and Cyprus. It is being grown in the environs of Almyros, Trikala, and Larissa.

The Mavra varieties grown in Thessaly include such local kinds as Mavra de Lamia, Mavra de Argos, Mavra de Kastellia, Mavra de Lokis, etc. They are either used domestically or exported to markets in Egypt, Algeria, and Morocco. There are two ecologic kinds of Mavra, *xirikas* (dry), those grown on mountain slopes, and *podistikas* (watered) those grown on the plains.

Bulgarian tobaccos

There are four main tobacco regions in Bulgaria—the Macedonian, Southern Bulgarian, Rhodopo-Thracian, and Northern Bulgarian. The two main types of Bulgarian tobaccos correspond with the Basma and Bachi-Bagli of Greece. The best varieties include Melnik, Nevrokop, Görna-Djumaja, Doupnitza, Khaskovo (Kochoukavak), Stanimaka, Kharmanli, Ortaköy, Kurdzhali, Perustitza, Petrich, and Plovdiv. Of these Melnik is conceded to be the best Bachi-Bagli although the Doup-

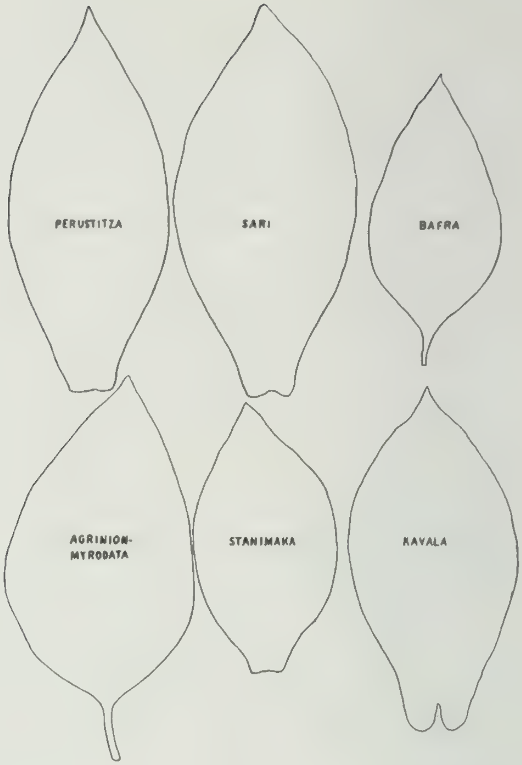


FIG. 41. Comparative average size and shape of leaves of aromatic tobacco varieties.

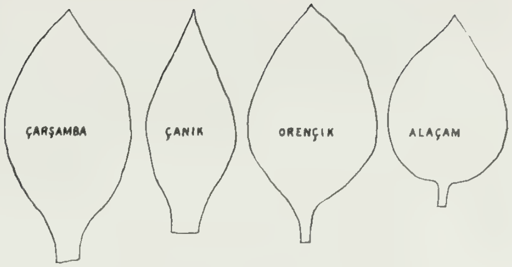
nitza is lowest in nicotine. The Ortaköy of the Rhodopo-Thracian region looks quite like Perustitza, and the Djebel Basma of this area is one of the most highly prized kinds. The tobaccos of the Northern Bulgarian region are used almost exclusively for the domestic markets. Some export markets look with favor upon the tobacco grown near Varna and Burgas in the northern Bulgarian region.

Turkish tobaccos

The Turkish tobaccos may be divided, according to districts, into four groups: (1) those of the Izmir region, (2) of the Marmara Sea and Thrace region, (3) of the Black Sea region, and (4) of eastern Turkey.

The tobaccos of the Izmir region are quite alike in that they have a sweet taste, fine texture, and, being neutral, are in good demand for blending. There are many varietal kinds and they have names that are derived from towns and villages near which they are grown. Ghiavour-

FIG. 42. Comparative average size and shape of certain varieties of tobacco from the Black Sea region.



köy and Botch are considered as of best quality. Other well-known kinds are Ayasolouk, Akhisar, Ödemiş, Lighda, Muğla, Thyra, Milas, Bergama, Manisa, and Balikesir. All are Izmir tobaccos, all are quite alike, and all differences among them are traceable to slight differences in soils and climate. Some regard each of the many Izmir kinds as ecological varieties. As a result of comparative trials at the Tobacco Institute at Cevizli-Maltepe and at Buça-Izmir the best variety has been found to be a selection called Izmir 64.

In general the varieties of the Marmara Sea and Thrace region, also called Anatolian region, are of the Bachi-Bagli type. They are derived mainly from seed from Samsun and Trabzon. The tobaccos are moderately aromatic, burn well, and have good filling properties. The most important varieties are Brusa, Duzçe, Gönen, Hendek, Izmit, and Thrace.

The tobaccos of the Black Sea region are second only to the Xanthi varieties from Greece and are in great demand in the cigarette industry. They are pleasingly aromatic, fine-textured, have a rich, light brown color, excellent combustion, and low specific weight. The varieties include Samsun, Bafra, Sinop, Tachova, Maden, Dere, Alaçam, Artvin, Djanik (Çanik), Evkav (Efkaf), Orençik, Çarşamba, Tokat, and Trabzon. They are mainly of the Bachi-Bagli type, but a few are Basma. Trabzon is usually topped, and as a result the leaves are large and high in nicotine content. The leaf is fine textured, reddish brown, and is used almost entirely for domestic consumption.

The tobaccos of eastern Turkey include Hatay, Malatya, and those grown near Adana, Gaziantep, and Bitlis. Together they constitute less than 10% of the Turkish tobacco crop.

Yugoslavian tobaccos

The only Basma type of importance grown in Yugoslavia is Prilep. It is grown in the Macedonian region that is contiguous to Greece and

Bulgaria, and also in Serbia. Its leaf is orange, and has excellent aroma, texture, and combustibility. Two other very good varieties are Strumitza-Yaka, and Kumanova (Otlja), derived from seed from the Xanthi region of Greece. In Serbia, on lateritic soil, such other varieties as Radowishta, Schtip, Dschevdschelia, Kawader, and Veles are grown. The total yearly production, according to Birkhead and Davis (1958), ranges between 30 and 35 million pounds. In the Adriatic regions such semiaromatic, large-leafed kinds or Herzegovina and Trebinjak (developed from Trabzon) are grown, the total annual production being between 40 and 50 million pounds.

Rumanian tobaccos

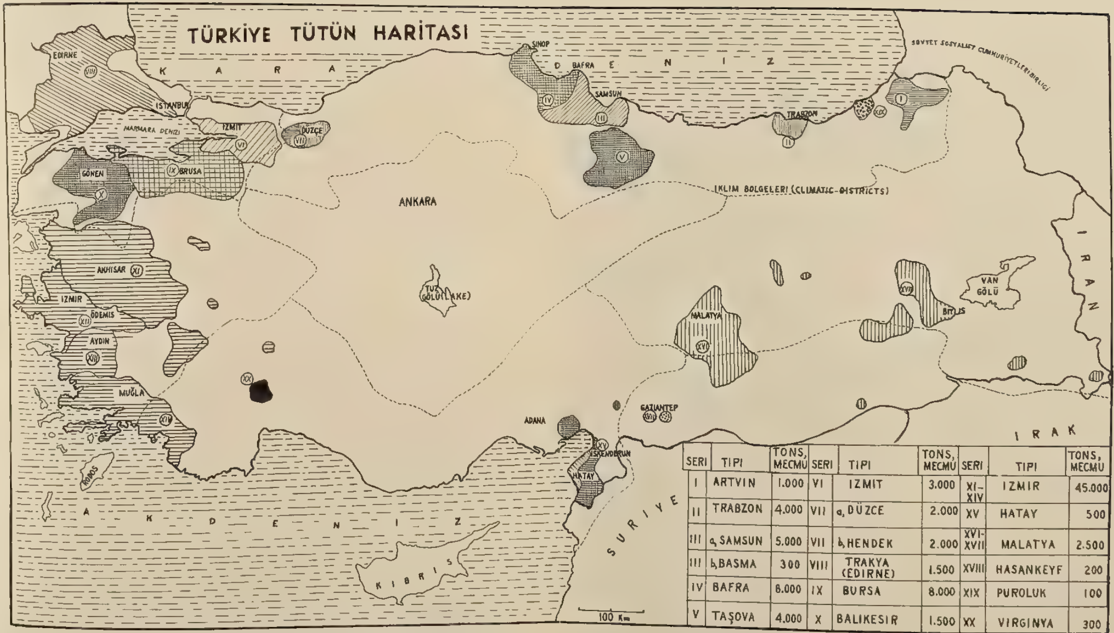
In southern and southwestern Rumania a limited acreage is devoted to aromatic and semiaromatic kinds. By use of seed from Greece, Yaka (Iaca), Solouk, Ghimpatzi, Molovata, Dragasani, Jalomitza, and Sătmărean are produced. These varieties provide tobaccos of good appearance, light color, and good filling power. Seed from the varieties Proseçan in Greece and Samsun in Turkey are planted in Rumania to grow varieties having these same names. The Bessarabian tobaccos from Xanthi-Yaka seed, grown along the northern border and extending into the U.S.S.R., provide a product that is very satisfactory as filler.

U.S.S.R. tobaccos

The Yalta-Dubek or Dzhubek variety grown in Crimea (Krim), is a kind that has been developed from Xanthi-Basma. The varieties grown in the Krasnodar area and along the eastern Black Sea coast and in Georgia and Armenia are known as Sukhumi, Georgian, Sochi-Adler, Kuban, and Maikop. Sukhumi (Sukhum) and Adler tobaccos are like Samsun, and Bafra-Sochi, Kuban, and Maikop were developed from Trabzon. Kuban tobaccos from the mountain regions are very aromatic and tasty. Samsun grown in the Sukhum region and Trabzon in the Sochi region are excellent aromatic kinds.

Italian tobaccos

In Italy three varieties of aromatic or semiaromatic tobaccos are being grown: Xanthi-Yaka, Perustitza, and Herzegovina. The Italian



SERI	TIPI	TONS, MECMU	SERI	TIPI	TONS, MECMU	SERI	TIPI	TONS, MECMU
I	ARTVIN	1.000	VI	IZMIT	3.000	XI-XIV	IZMIR	45.000
II	TRABZON	4.000	VII	a, DÜZCE	2.000	XV	HATAY	500
III	a, SAMSUN	5.000	VII	b, HENDEK	2.000	XVI-XVII	MALATYA	2.500
III	b, BASMA	300	VIII	TRAKYA (EDIRNE)	1.500	XVIII	HASANKEYF	200
IV	BAFRA	8.000	IX	BURSA	8.000	XIX	PUROLUK	100
V	TAŞOVA	4.000	X	BALIKESIR	1.500	XX	VIRGINYA	300

FIG. 43. Map of Turkey (adapted) showing the areas in which each of the different varieties is being produced. The numerals represent the kinds. Total yield of each kind is given in metric tons. Additionally about 100 tons of *tonbeki (Nicotiana rustica)* are produced each year.

Xanthi-Yaka tobaccos differ from the genuine Xanthi-Yaka grown in Greece in that the leaves are larger and less aromatic, but they are equally bright-colored and light in specific weight. They are cultivated in the province of Puglia in the districts of Bari, Brindisi, Lecce, Foggia and Taranto; in the province of Basilicata in the districts of Matera and Potenza; and in the province of Abruzzi in the district of Pescada. Perustitza is being grown in Puglia in the district of Lecce; in Abruzzi in the districts of Chieti, Pescara, and Terame; in Molise in the district of Campobasso; in Campania in the districts of Benevento and Salerno; in Lazio in the districts of Frosinone, Latina, Rieti, Roma, and Viterbo. Herzegovina is being grown in Puglia in the district of Lecce; in Abruzzi in the district of Chieti; in Lazio in the district of Frosinone; in Sardinia in the district of Sassori; and in Sicily in the district of Ragina. Efforts to grow Samsun, Trabzon, Proseçan, Perustitza, and Herzegovina have met with rather poor success, as the product lacks quantity and quality of aroma, as well as sufficient filling power.

Grading practices

Final classification or grading of aromatic tobaccos occurs after the crop has been delivered and sold at the storage depot. Here it is sorted and baled, sorting being the first step in manipulation. In sorting, the leaves are separated according to color, texture, size, freedom from defects, etc. But in all countries, as previously stated, the primary basis for grading depends upon the stalk position of the leaf, although the terminology may be different in each country. As a secondary basis, account is taken of the way that the leaves are arranged in the final bale. For example, any Xanthi-type lot of tobacco produced in the Macedonian region of Greece near Drama, Serrai, Zichna, etc., that is of superior or Basma quality consists of leaf produced on the upper portion of the stalk. It is termed *Maxoul,* whereas leaf from the lower portion of the stalk is *Sira-Pastal.* Thus leaf of the *ütch* and *ana* positions in all classification systems is *Maxoul.* Each of these two groups, in turn, may be divided into Roman numbered grades, I being choicest leaf from the last priming in the *Maxoul* class. Similarly, Bachi-Bagli kinds from the upper portion of the stalk become *Rendement,* and from the lower portion, "Second Quality." Ordinarily each of these is sorted into numbered grades. In some areas letters are used instead of numbers.

Merchants within Greece and Turkey employ subgroups within the basic grade groups, as determined by stalk position. These subgroups, for example, may make use of numerals, both Roman and Arabic or Arabic alone. The bases for these subgroups are such physical features as texture, aroma, color, etc. Under this system there are four (IV) groups, the first three of which are regarded as exportable tobaccos. The best grade, for example, may contain 1_1 and 1_2; the second grade may contain 2_1 2_2 2_3; the third grade may contain 3_1 3_2 3_3 3_4; the fourth grade contains the Kappa and may be divided into K_4 and K_5, the former being the better. When the leaf is manipulated at the magazines or storage depots *Refusa* constitutes the non-usable leaf, and *Kirinti* the broken bits or scrap.

Formerly tobaccos were baled in classical fashion as *Basma, Bachi-Bagli, Kaloup,* or *Tonga,* which differed essentially in the arrangement of leaves within the bale. In both *Basma* and *Bachi-Bagli* bales the sorted leaves, arranged in *demets* or *pastals* (hands), are carefully layered patternwise in making the bale. Each *pastal* is tied separately in *Bachi-Bagli* bales, but remains untied in *Basma* bales. In *Kaloup* bales the strings of tobacco (*armathas*) are so placed that the bases of the leaves are directed toward the outside of the bale, and in the same direction in the inner layers. In *Tonga* bales, the leaves are placed completely without order, i.e., loose-leaf order.

In all types of bales *Maxoul* consists of leaf from the *ütch* and *ana* groups, whether the groups are kept separate or whether they are mixed as is done in "American" type bales. The defective leaves, whatever the cause of the defect, are removed from *Maxoul* during sorting. Such defective leaves may be placed among those of the dip group, in which case the bales become "manipulated *tongas.*"

The tobaccos of the Black Sea region of the first, second, and third qualities are called *Bitchak,* those of fourth quality, *Bali-Bitchak,* and those of lesser quality *Görmes.* Leaf that is discarded while being sorted, because of physical damage, is kept separate and becomes *Kirinti* (pieces).

Standardization of grades among aromatic tobaccos is regarded by some as an essential future practice. To do so would be an exceedingly difficult matter partly because of differences among the four major types and the large number of named varieties within each type. A workable system that is understandable and serviceable both for the seller and the buyer demands that the system be simple, i.e., consist of a small number of markedly different grades.

Summary

There are four major groups of the aromatic type of tobacco: Xanthi, Samsun, Kavala, and Izmir. Within each, there are many agronomic varieties. The classification of aromatic tobaccos is based mainly upon quality as determined by leaf position on the stalk. Quality tends to increase progressively upward from the base of the stalk to the tip. In harvesting five to eight hands are primed. While the names applied to the hands differ among the different countries, all are based upon those used by the Turks, who first cultivated tobacco in the Near East.

Aromatic tobaccos are baled as *Basma, Bachi-Bagli, Kaloup,* or *Tonga.* The first two methods are the classical ones, but in recent years, for economic reasons, they have been supplanted largely by the *Tonga,* or loose-leaf, method.

Standardization of grades within each of the four major groups has been accomplished to a degree that is well understood and is serviceable. Whether the presently used grading system should be supplanted remains problematic.

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Chapter Seven

CULTIVATION OF AROMATIC TOBACCOS

Consideration will be given herein to practices employed in growing aromatic tobaccos and in harvesting and curing the leaf. It should be emphasized at the outset that experience gained from the cultivation and handling of other types of tobacco is of very limited value to a grower of aromatic tobaccos. In fact, it may constitute a serious handicap to him for the reason that he may be convinced that he already knows all about cultivation of tobacco, hence will not follow instructions when attempting to cultivate aromatic tobacco. By rule-of-thumb procedures gained from years of experience, tobacco growers in the Near East have learned what to do, how to do it, and when to do it. This is not to say that the methods which they employ currently could not be modified with benefit. They have acquired the art of growing this type of tobacco but apparently are quite lacking in knowledge of the underlying scientific principles that govern its production and curing. Investigators have sought to understand the scientific aspects, but their efforts have yielded only a limited measure of success, and much remains to be learned. In the discussions that follow emphasis will be placed on the interdependence of art and science in the cultivation of aromatic tobacco, and, so far as possible, detailed instructions will be given on how to grow and handle this type of tobacco in a manner to secure a product of satisfactory quality and yield.

Seedbeds

In all tobacco-growing regions and with all types of tobacco eventually the same basic principles are involved in the preparation, seeding, and management of seedbeds. As a prime requisite the grower must have a sufficient supply of vigorous, healthy seedlings for transplanting at the proper time. This will practically insure a uniform quality from each priming. To do this careful attention must be given to the selection of a seedbed site, to tilth of the seedbed soil, to its freedom from weeds, soil-borne pests, and disease-producing micro-organisms, to amount and kind of fertilizer applied, to construction of the seedbed, to provision of an adequate supply of water for purposes of irrigation, and to protection of the seedlings from damage by weather, insects, and pathogenic organisms.

Location—As regards location, seedbeds may be made on the same site for a period of years or new sites may be used each season. Whether permanent beds or temporary beds are employed depends upon the availability of suitable sites, and upon the need for treating the soil prior to seeding to control noxious weeds, pests, and diseases. Places located on gentle slopes having a southern or southeastern exposure are preferable. Such sites provide the best exposure to sunshine and warmth, and to avoidance of cold, drying winds. Drainage must be sufficient to prevent flooding or water logging. Steep slopes must be avoided to prevent erosion. If the terrain is quite level it may be advisable to construct the beds so that the surface is higher than that of the surrounding land, a universal practice in the Near East. Also, in regions having heavy rains it may be necessary to construct ditches around the beds or between them to drain away excess water.

Mellow, loamy soils, well aerated and rich in organic matter are essential. Such soils have good moisture-holding capacity. Heavy, compact soils, especially those having impervious subsoils, are poorly aerated and may become water-logged, hence are to be avoided as seedbed sites. If newly cleared woodland sites are selected, the stumps, roots, and brush should be removed first and then the surface soil should be thoroughly pulverized to a depth of five to six inches with a disk harrow. The topsoil should not be turned under by plowing. Several diskings may be required to provide the proper tilth. After disking, the soil should be pulverized further, smoothed, and leveled by use of a garden rake.

The fertilizer may then be applied, after which the seed may be sown. Incekara (1958) states that in Turkey, after the soil has been carefully prepared, the beds are covered with a three-inch-deep layer of leaf mold that has been mixed with well-decomposed sheep or goat manure, two to three parts of leaf mold to one part of manure. In Greece, in permanent seedbeds, the soil is removed each season and is replaced with a mixture of 50% clay and 25% sand, taken from a new location, the remainder of the mixture being well-rotted manure. However, permanent seedbeds are rarely used there.

Soil sterilization—It is highly desirable, when permanent seedbed sites are employed, to prevent the germination of weed seed and to control soil-dwelling or soil-borne insect pests and disease-producing organisms. Partial but effective soil sterilization has been accomplished by use either of heat or of chemicals. Either dry heat or steam is equally effective for this purpose. A suitable dry-heat sterilizer consists of a sheet-iron fire box upon which a pan is placed to hold the soil. After heating the soil for thirty to sixty minutes, the pan is emptied, then refilled. Two men, by use of this method, can treat the soil for a 100-square-yard bed in a day.

The equipment for steam heating is a portable steam boiler and one or two galvanized iron pans with dimensions of 8 to 10 feet long × 6 feet wide × 8 to 10 inches deep. The pan is inverted, the edges pressed into the soil, and live steam is admitted through a hose extending from the boiler to an inlet in the pan. If it is necessary to save time, two pans may be used alternately. A steaming period of thirty minutes duration is sufficient if moist but not wet soils are being treated.

Among chemicals that have been found to be effective as fungicides, bactericides, nematocides, and weed killers are formaldehyde, uramon, cyanamide, chloropicrin, and methyl bromide. These chemicals must be used carefully according to directions furnished by the manufacturer.

Formaldehyde ($HCHO$), 40%, diluted 1 part to 50 parts of water may be applied with a sprinkling can, applying one gallon of solution to two to three square feet of area. Incekara (1958) recommends mixing 110 ml. of formaldehyde with sawdust for application to each square meter of seedbed area to be treated. Most effective results are secured if the treated soil is covered promptly with a canvas, for two or three days, to prevent the rapid escape of fumes.

Uramon, one pound, when mixed with one-half pound of cyanamide ($CNNH_2$) for each square yard of seedbed surface, is very effective in inhibiting germination of weed seeds, killing root-knot nematodes and certain species of soil-inhabiting pathogens. The mixture should be applied broadcast, then mixed with the soil by use of a rake. But these materials have a residual effect upon tobacco seedlings unless the chemicals are leached away. For this reason they should be applied at least ninety days prior to the time for seeding.

Chloropicrin (CCl_3NO_2) is difficult and unpleasant to handle. About 15 pounds are required per 100 square yards of seedbed. It must be injected three to five inches beneath the soil surface, using a special applicator.

Among chemicals used for soil treatment methyl bromide (CH_3Br) is most favored. A minimum of 9 pounds of this chemical for each 100 square yards of seedbed area is required. For its use one needs the following equipment: (1) a plastic cover of sufficient size to treat 100 square yards at a time; (2) three flat pans of ½ gallon capacity or larger; (3) three pieces of plastic hose; (4) one jiffy applicator; (5) three weights, preferably bricks with holes in them; (6) twenty or thirty bags filled with straw.

Procedure:

1. Thoroughly prepare the soil for the seedbed.
2. Plow a furrow around the bed, to permit the plastic cover to lap into the furrow on all sides.
3. Place the bags of straw so as to keep the plastic cover from contact with the ground.
4. Arrange the three flat pans, pressing them firmly in the ground to prevent them from tipping over.
5. Anchor each hose, by means of the perforated bricks, so that one end will be in the pan and the other end will extend outside the seedbed a distance of two or three feet.
6. Place the cover over the bed, anchoring the edges in the furrow by partly filling the furrow with soil. Guard against compressing the plastic hose.
7. Connect the applicator to the end of the plastic tube that is outside the seedbed.
8. Place the can of methyl bromide, bottom side down, in the applicator and pull the lever. The hollow plunger penetrates the side of the can, allowing the methyl bromide to flow through the plastic hose to the flat pans. For 100 square yards of bed, empty three one-pound cans into each of the three flat pans.
9. Leave the covers in place for twenty-four hours if the temperature is 60° F. or above, but longer if the temperature is 50° F.
10. The bed may be sown five to seven days after the soil has

been treated, but it is better to treat the soil two or three weeks before sowing the seed to allow all of the fumes to disappear from the soil.

Seedbed fertilization—Throughout the Near East mineral fertilizers are not used in seedbeds or in fields. But the application of mineral fertilizer to seedbeds just prior to seeding is a widely used practice with other types of tobacco throughout nearly all other tobacco-producing regions. Superphosphate constitutes a good source of phosphorus. Sulphate of potash or the double salt, sulphate of potash magnesia, are the best sources of potassium. The use of chloride of potassium (muriate) is to be avoided. Organic sources of nitrogen are preferable to nitrate of soda to provide the necessary nitrogen. Mineral fertilizers especially formulated for tobacco seedbeds are available and approximately 20 to 25 pounds per 100 square yards of seedbed surface constitute an ample application. The fertilizer should be applied broadcast after the soil surface is loosened and smoothed and should be mixed thoroughly with the upper 2 or 3 inches by raking. The seedbed is then ready to receive the seed.

Seeding—As stated previously, an ample supply of seedlings of uniform size at the proper time for transplanting is absolutely essential for production of high quality aromatic tobacco. Without such supply it is impossible to secure a uniform stand. To meet this requirement the seedbed size should be ample and the population of seedlings should be neither too sparse nor too dense. To produce 60,000 to 70,000 seedlings, the number required to plant an acre, requires approximately 300 square yards of seedbed. Three to four teaspoonfuls (level) should be seeded onto each 100 square yards of seedbed area. In Turkey, a field of one dekar, (one-quarter acre) requires 15,000 to 20,000 seedlings that can be grown by sowing five grains of seed in a seedbed of five square meters. Throughout the Near East generally seedbeds are so thickly seeded that spindly seedlings are produced. In consequence survival at transplanting is not so satisfactory as would result if the seedbeds were less thickly seeded.

Such small seeds as those of tobacco, if they are to be distributed uniformly, should be thoroughly mixed with fine sand, fertilizer, sifted wood ashes, infusorial earth, or cottonseed meal, with one quart of diluent for each teaspoonful of seed. It may be advisable to compact the surface or to firm it immediately after seeding if the soils are loose-textured, using a roller or tamper. A device for tamping can be made with a board attached to a handle. If the soil is heavy a light brushing with a broom made of a bundle of twigs will disturb the surface soil sufficiently to cover the seed. At time of seeding, if the soil surface is dry, it may be moistened by sprinkling carefully.

Construction of beds—Growers are well advised to frame the beds or construct the borders prior to sowing. They may use either rough 1 × 8 or 1 × 10 inch boards or else poles six to eight inches diameter. Those who prefer tight beds use boards sawed square on the ends. Beds elevated above the terrain do not require wooden borders. The beds may be of any convenient length but the width should not exceed two or three yards. Such operations as weeding, dusting, spraying, applying fertilizer as top dressing, removing or replacing the covers, and drawing or pulling plants for transplanting can be accomplished readily without stepping on the beds if they are never framed and their width does not exceed two to three yards. Beds in the Near East never exceed a meter in width. As soon as the beds are sown they should be covered, although growers in Greece and Turkey seldom cover the seedbeds. Framed beds should be covered with cloth covers having twenty-four to twenty-eight threads per square inch. These covers are fastened in position by means of six-penny finishing nails, driven part way in below the edges of the frames, and spaced about fifteen inches apart. The covers should be stretched tightly over the edges of the frames and should be fastened over the heads of the nails. If the beds are not framed, a trellis-like structure consisting of forked branches set in the ground vertically and thin poles arranged horizontally is used to support a thatched roof or cover. Reeds, grass, fern fronds, or other similar materials comprise the roof or cover. Covers serve to protect the seedlings from intense sunshine and heavy rains.

Throughout the Near East there are two types of construction of seedbeds, the open type (called *agik yaştik* or *kara yaştik* in Turkish) and the closed typed (called *kapali yaştik*). The former type is the one most widely employed. Open type beds are long narrow beds, the surface of which is slightly elevated above the surrounding terrain, with paths between the beds. They lack completely protection from inclement weather and hence may fail to produce sufficient seedlings to set the crop. Closed seedbeds, if provided with glass or plastic covers, are very satisfactory but are too expensive for general use. Cloth covers

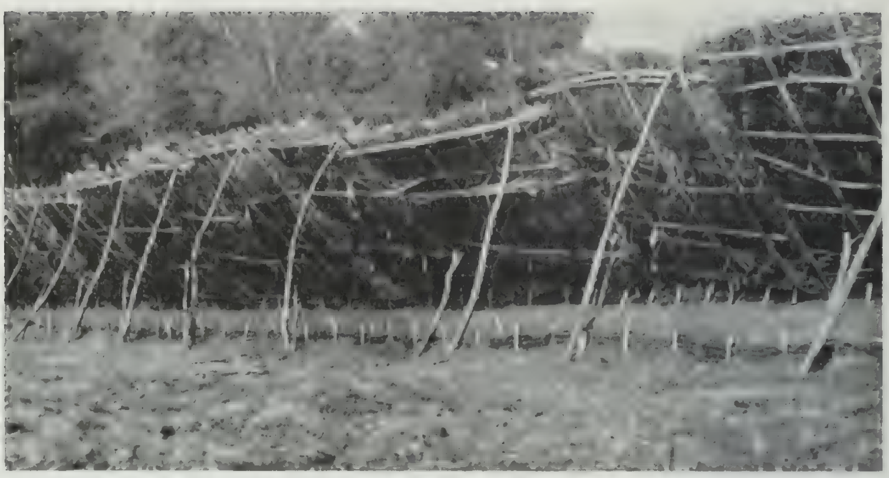


FIG. 44. Open type of seedbed in Turkey, called *acik yastik*, with windbreak made of *Vitex agnus castus* L, a native shrub. Courtesy F. Ipecoğlu.

do not appear to be suitable there. Some growers in the Aegean region use a native shrub, *Vitex agnus castus* L., to make a kind of cover called *rapanca*.

The date of seeding varies greatly even in the same region. Since the seed will not germinate until the soil becomes warm, seeding in midwinter rather than in early spring is inadvisable. A period of fifty to

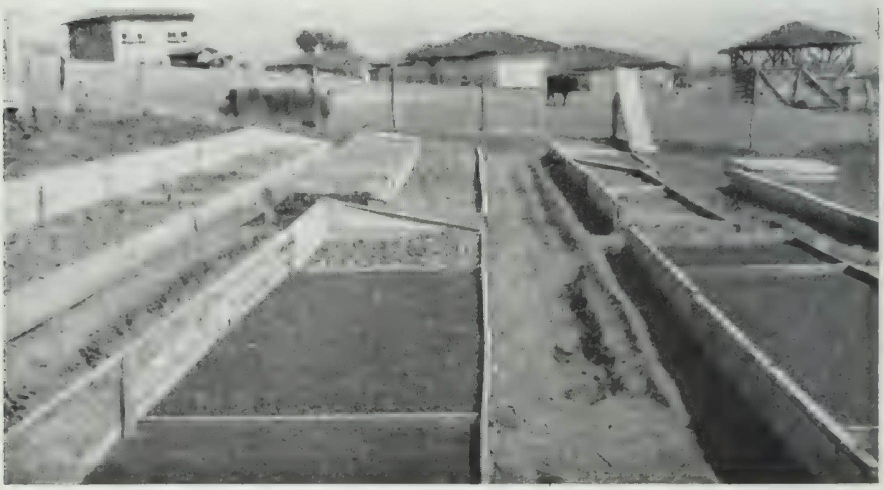


FIG. 45. Framed seedbed covered with sash, called *kapala yastik*, in Turkey in an open field near a village. Courtesy F. Ipecoğlu.

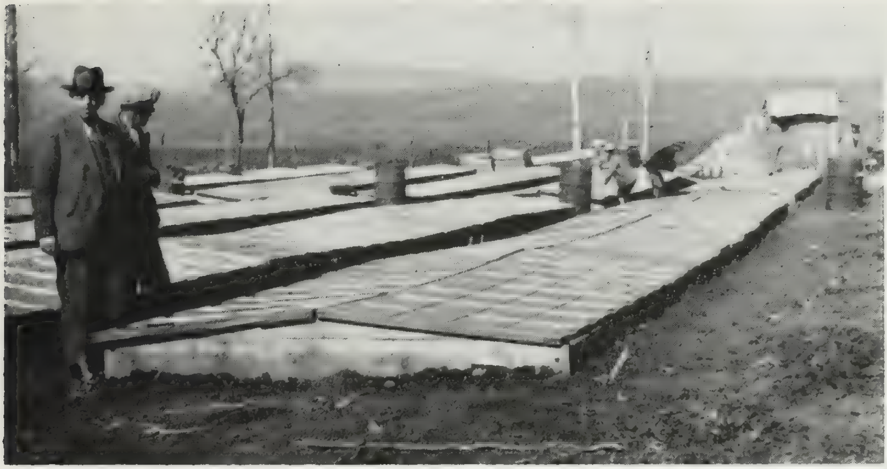


FIG. 46. A wide seedbed in Turkey, covered with two tiers of sash. Water for irrigation is stored in the barrels. Courtesy F. Ipecoğlu.

sixty days is required from time of germination until the seedlings, grown outdoors, are of sufficient size to be transplanted.

Care of seedbeds—An indispensable adjunct to the proper care of seedbeds is an adequate water supply, either a stream, pond, or well with adequate pumps and pipes, or even an installed irrigation system. A lack of water may seriously interfere with the growth of young plants or in a period of drought may stunt them or even cause their death.

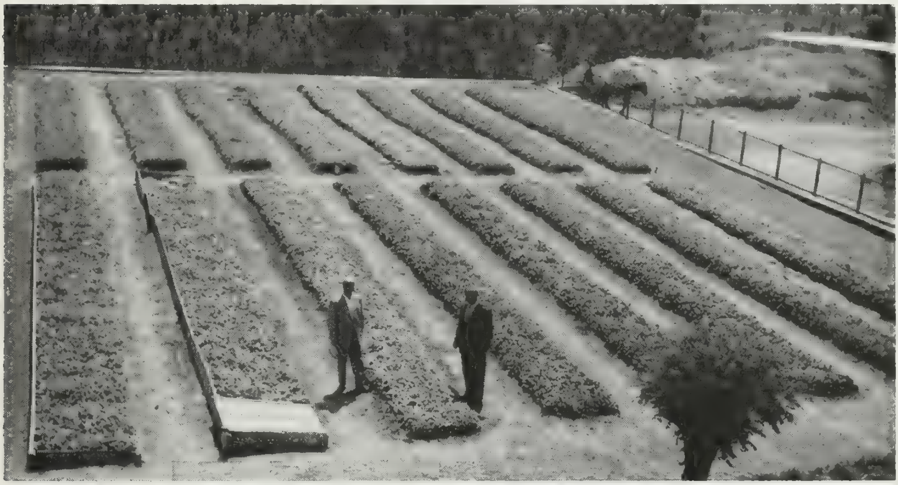


FIG. 47. Well-constructed, communal, narrow seedbeds, in Turkey, from which the covers have been removed. The seedlings are of transplantable size. Courtesy F. Ipecoğlu

Frequent inspection of the beds is necessary to guard against insect infestation or disease outbreaks. Such inspections are best made by loosening the cover along one side of the seedbed. If insect damage or disease outbreaks are detected early they may be checked by use of insecticidal or fungicidal sprays or dusts. In the United States, for example, downy mildew occurs every year, making it necessary to apply fungicides one or more times every week, depending upon weather conditions.

When rainfall is abundant, the mineral fertilizer may be leached out to the extent that the seedlings will have a yellow-green color. In such event top dressing is indicated. For this purpose a solution containing 3 to 5 pounds of nitrate of soda dissolved in 50 gallons of water should be applied to each 100 square yards of seedbed.

Promiscuous visitation of neighboring seedbeds is contraindicated because it increases the likelihood of transferring micro-organisms that may adhere to the shoes, clothing, or hands. Workmen who attend the seedbeds should refrain from using chewing and smoking tobacco while weeding, pulling plants for transplanting, or otherwise handling young plants. It has been well established that the virus of the mosaic disease

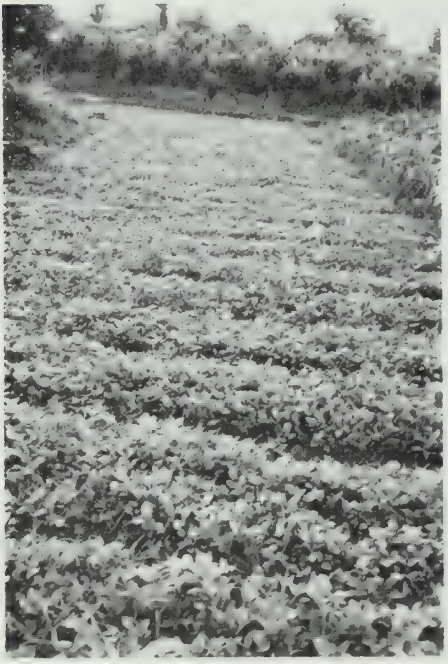


FIG. 48. Open type of thickly sown seedbeds of a kind most usually used in Turkey. Seedlings were being transplanted from these beds in fields near Brusa.

is transmitted by the careless use of tobacco, and that the transplanting of a few diseased seedlings may be the source from which the entire field of tobacco may become diseased by harvest time. This disease is known to reduce seriously both yield and quality.

As the season for transplanting approaches, the covers should be removed to expose the young plants to full sunlight and thus to permit them to become less tender. As a result of such exposure just prior to transplanting the plants are better able to withstand setting in the field. The length of this period of exposure should be about seven to ten days, depending upon the prevailing weather. At this time too the covers may be dried and stored for use during the next season. Whether the seedbeds occupy permanent or temporary sites, they should not be abandoned after the close of the transplanting season. If boards are used to frame the beds, they should be removed and properly stored for use in subsequent years. Then the young plants that remain should be destroyed by plowing or disking. Otherwise these plants may harbor insects, pests, or disease-producing agents. If the area is to serve as the seedbed site for the succeeding year, it should be planted with some crop that can be plowed under as green manure. Thickly sown soybeans, corn, or other forage crop will check growth of weeds and will supply the organic matter needed to maintain tilth.

In Greece and Turkey, as soon as the season for transplanting is over, the seedbeds sites are usually planted with such vegetable crops as beans, onions, beets, etc., but in some instances may be abandoned entirely.

Soils of the Near Eastern aromatic tobacco regions

One of the primary factors governing the growing of aromatic tobaccos is type of soil, although in the cultivation of oriental tobacco a variety of soils has been used more or less successfully in different parts of the world. The soils of Greece, Turkey, and Italy, predominantly suited for this type of tobacco, are mountain soils of the lithosolic group. As the name indicates, lithosolic are "rock soils' that occur on the slopes or near the base of mountains. The surface layers are thin or shallow, are very stony throughout, are underlain with rock, and are of low productivity. According to Kubiena (1953) there is an extensive zone of forest soils, extending from Italy throughout southern Europe and into Asia Minor, from which the forests have been largely removed. He designates one of these groups "Terra Rossa," the soils of which have been derived from the disintegration of granitic and limestone parent rocks. The A horizon is feebly developed, and the B horizon is underlain with parent material of white chalk. The red color is due to their content of ferric hydroxide.

The soils of the Macedonian and Thracian area on which the best quality of oriental tobacco is being grown are upland forest soils, designated brown podsols, red and yellow podsols, and Mediterranean dry forest soils. These podsolic soils generally are light textured and of low to medium productivity. The brown soils are high in calcium carbonate, granular, dark brown to reddish brown in color, shallow, and of medium productivity. The red and yellow podsols have a grayish surface layer but the clay subsoils are red or yellowish. They are acid, low to medium in organic matter and productivity, and of good soil structure. The soils of the dry Mediterranean group range from very sandy to clay, and are alkaline to slightly acid. Some of them are developed from limestone, and all are shallow and low in humus. Others have arisen from non-limestone parent material and have a reddish brown B horizon.

In the Aegean region the Terra Rossa soils predominate, but the best tobacco is grown there on soils derived from schists. The soils are heavy, red, low in organic matter, and alkaline, and are difficult to work when dry. They tend to become more shallow near the coast and to contain a considerable proportion of sand, as occurs around Ayasolouk and Soke. Swampy areas, when drained, have black soils, due to the organic matter. The soils in many places are underlain with limestone, and it is not unusual to find limestone outcrops.

Tobacco is grown in the Black Sea region in a bordering zone of upland brown forest soil. This zone is backed by mountain soils of the lithosolic group on which tobaccos of excellent quality are being grown. The content of organic matter blackens the clay soils of this bordering zone. They are very sticky when wet, so sticky in fact that vehicular traffic on unpaved roads in this area is quite impossible. They are very hard and cloddy and very difficult to cultivate when dry. The soils of the mountain slopes there are light chocolate brown to deep reddish brown. Also in the Black Sea region, as is generally the case throughout the Near East, the best quality leaf, *djebel,* is produced on shallow rocky clay soils of the mountain crests and high valleys, and that of the rocky slopes, *yaka,* is superior to *ova,* that grown in the deeper colluvial soils of the valleys.

Soils of Africa

Taylor (1924) states that on soils in Southern Rhodesia good aromatic tobacco can be grown on sandy, clay loams derived from granite or schist. The color and combustibility of leaf grown on sandy soil derived entirely from granite is good but the leaf lacks body. Stella (1923) found that the reddish soils of the Western Province of the Union of South Africa, which contain about 30% clay, are most suitable but that good aromatic tobacco can be grown also on gray sandy loams.

Soils of Venezuela

In Venezuela friable, lateritic soils, low in organic matter, have been found suitable for the production of aromatic tobaccos. These soils are low in organic matter. They respond well to the use of fertilizers. There the growing crop must be irrigated, since it must be grown during the dry season.

Soils of the southeastern United States

In the southeastern United States, the clay soils of the Piedmont region are more suitable for aromatic tobacco than are the sandy soils of the Coastal Plain region. Slow, uniform growth throughout the entire season, requisite to the development of quality of the crop, is promoted by clay soils, whereas the plant tends to grow rapidly and the leaf tends to lack body and aroma when tobacco is grown on light, sandy soils. These clay soils of the southeastern United States, all of which have clay or clay loam subsoils, have been divided into four major groups, as follows: (1) sandy clay loams, having 42-75% clay, 20-35% sands, and less than 28% silt; (2) clay loams, having 20-40% clay, 20-45% sand, and 15-40% silt; (3) silty clay loams, having 60-75% silt, 27-40% clay, and less than 20% sand; (4) sandy clays, having 45-65% sand, and 35-55% clay.

Sites of fields

Well-drained slopes or crests of ridges with good air drainage and protection against damage from prevailing winds constitute the most favorable sites for fields of aromatic tobacco. Fields that are flat and low-lying are to be avoided. In Greece large fields are planted in broad valleys, having gently sloping land. Many fields in the Marmara Sea region and in the Aegean Sea region occur on similar sites. In the Black Sea region slopes that face the east and northeast are much preferred.

In general, soils low in natural fertility, but not impoverished soils, should be employed. It has been found both in the Near East and in the southeastern United States that a given field may return poor yields when planted with cotton, corn, or small grains and therefore will be judged to be low in natural fertility. Such fields, however, may be found to have soils that are heavily infested with root-knot nematodes or with meadow nematodes. Planting aromatic tobacco on such fields will almost always result in crop failure.

Growers of the Near East prefer to plant tobacco on the more fertile, well-drained valley soils because they produce three to four times larger per-hectare yields than in fields planted on mountain slopes. They attempt to compensate for greater natural fertility by close spacing, and it is not unusual to find rows eight to nine inches apart and the intervals between plants three to four inches. However, quality of the leaf tends to be less, and the respective governmental agencies strongly advise against using such sites.

Quite generally, in the Near East, tobacco is grown in the same fields year after year, due to the scarcity of arable land. This fact becomes meaningful when it is appreciated that only about one-sixth of the total land area of Greece is arable. Such scarcity makes it difficult to employ a system of rotation. It has been demonstrated there, and in Turkey as well, that a rotation system for tobacco which employs wheat or other cereal crops, is a good practice.

Whether fields that have been cropped with legumes during the preceding year are suitable sites for a crop of aromatic tobacco remains problematic. The residue of nitrogenous materials left in the soil from a leguminous crop may promote too rapid growth, and the leaf may not mature properly or have a desirable color and aroma when cured. Legumes in rotation may not prove to be harmful everywhere for very infertile soils, but they are contraindicated for soils in the southeastern United States.

Preparation of the field

In preparing the field for a crop of tobacco in the United States it is a good practice to plow deeply in the fall, but not to a depth to bring subsoil to the surface. The field should then be seeded with rye, oats, or wheat as a winter cover crop. If the field has borne a crop of tobacco and is to be used for tobacco during the next year the stalks and weeds should be plowed under as soon as the harvest has been completed. If barnyard manure is available, eight to ten tons per acre should be applied prior to plowing in the fall. In early spring, at least a month prior to time for transplanting, the field should be plowed again to turn under the cover crop and permit it to decompose. It should then be disked and harrowed sufficiently to bring the tilth to a good state. If the field is thoroughly prepared, the plants will grow well and cultivation of the growing crop is greatly facilitated.

In the Near East generally, it is the practice to use the same field for tobacco for three to five successive years. Then follows a period in which the land is rested by the use of cereal crops. As soon as possible after the tobacco harvest is ended, the fields are plowed to a depth of nine to ten cm. (approximately three to four inches). Later in the fall after the rains have come these fields are plowed deeply, eighteen to twenty cm. (approximately seven to eight inches), depending upon the depth of the soil. Then in spring in order to provide good tilth prior to transplanting, the fields are plowed again to a depth of approximately six inches, and the surface is smoothed with a drag or a harrow. Immediately before transplanting rows of shallow furrows are opened into which the seedlings will be transplanted.

Mineral fertilizers

As a rational basis for the application of commercial fertilizer for a crop of tobacco account must be taken of the results of soil analysis made prior to planting to determine the amounts of residual available mineral elements. Additionally one should know the approximate amounts of minerals required to produce the crop. Such data for a crop of aromatic tobacco are not available. Data bearing on the amounts of minerals removed by crops of cigar tobacco however are given by Garner (1951). One may assume that aromatic tobacco and

TABLE XX. CROP YIELDS PER ACRE ON A 20% MOISTURE BASIS, AND AMOUNTS OF MINERAL NUTRIENTS TAKEN UP BY THE CROPS

Yield, lbs.	*Part of plant*	*N*	P_2O_5	K_2O	CaO	MgO	SO_2
800	leaf	13	3	16	19	2.5	5
400	stalk	8	1.5	8	2	1	1.5
	total	21	4.5	24	21	3.5	6.5
1200	leaf	34	6	36	44	7	10
800	stalk	22	4	22	5	3	5
	total	56	10	58	49	10	15
1500	leaf	60	9	84	72	12	18
1300	stalk	40	7	52	10	6	10
	total	100	16	136	82	18	28

other types should need approximately similar amounts of minerals. Garner's data are shown in Table XX.

In the Union of South Africa Strydom and Malherbe (1939) found that a crop of Turkish tobacco grown on one morgen (2.1 acres) removes the following amounts of minerals.

In general, mineral or commercial fertilizers are not used in the Near East but instead the soils are enriched by applying manure. Incekara (1958) states that, in Turkey, after a field has been planted to tobacco for several years it is advisable to pen sheep or goats on the land during the months of late winter. The manure from these animals may then be incorporated with the soil when afterward the land is plowed in preparation for planting. Manure from farm animals everywhere appears to be the best source of the essential elements of nutrition for a crop of aromatic tobacco. As manure decomposes its constituent elements are slowly and continuously available to the growing crop, and, additionally, the residues serve to increase the humus con-

TABLE XXI. CROP YIELD PER MORGEN AND MINERALS REQUIRED BY TURKISH TOBACCO

Yield, lbs.	*Part of plant*	*N*	P_2O_5	K_2O	CaO
1400	leaf	28	7	42	40
600	stalk	12	5	14	6
	total	40	12	56	46

tent of the soil and thus to increase its water-holding capacity, its aeration capacity, and to improve its physical texture.

Even though growers of aromatic tobacco throughout the Near East do not now use commercial fertilizers, experiments conducted at the experimental stations in Drama, Xanthi, Cevizli-Maltepe, and Samsun demonstrate that this crop responds to its use by improvement both of quality and quantity. The differences between plots that received an application of a complete fertilizer as compared with those to which no fertilizer had been applied are very marked. At each station phosphorus is limited, even though nitrogen and potassium are applied in ample amounts. But whether it will become the practice to apply commerical fertilizers throughout Greece and Turkey and neighboring countries depends upon whether it becomes necessary to produce larger yields to meet market demands and upon the need to employ the limited arable lands for other kinds of crops.

In growing aromatic tobacco, all observations indicate that mineral or commercial fertilizers are to be employed only when manure is not available or else to supplement the application of manure. In Southern Rhodesia, Taylor (1924) recommends the application of 300 pounds per acre of 4% nitrogen (as blood meal), 8% P_2O_5, and 4% K_2O as sulphate, if the fertilizer is applied in the drills; and of 400 pounds per acre, if broadcast.

In the Piedmont region of the southeastern United States soils of average fertility require a per acre broadcast of 300 to 400 pounds of superphosphate, 125 to 250 pounds of sulphate of potash, and the equivalent of 10 to 15 pounds of nitrogen in the organic form. For the less fertile soils, experience has shown that either one of the following mixtures and amounts per acre is satisfactory: (1) 600 to 800 pounds of 2-8-10 plus 0-100 pounds of superphosphate plus 25 to 150 pounds of sulphate of potash; (2) 400 to 500 pounds of 3-9-9 plus 125 to 225 pounds of superphosphate plus 50 to 175 pounds of sulphate of potash; (3) 300 to 400 pounds of 4-8-12 plus 200 to 300 pounds of superphosphate plus 50 to 175 pounds of sulphate of potash; (4) 300 to 400 pounds of 4-12-12 plus 125 to 225 pounds of superphosphate plus 50 to 175 pounds of sulphate of potash.

Shaw (1954) made a series of field trials with aromatic tobacco, extending over a period of four years, to determine the fertilizer requirements of soils in western North Carolina. He employed superphosphate (20% P_2O_5) at the rates of 0, 40, and 160 pounds per acre, with

80 lbs K_2O as potassium sulphate and 20 pounds of nitrogen as cottonseed meal. Additionally, on all plots three tons per acre of dairy barn manure were applied. Average yields of 986, 1065, and 1311 pounds per acre were secured, thus showing the influence of a high level of phosphorus. He also found that K should be abundantly available, but 20 pounds of nitrogen per acre was adequate. Large leaf size and low quality resulted when nitrogen was supplied in excess of 20 pounds per acre.

By avoiding the use of readily available nitrogen, conditions are provided to permit the leaves to mature properly and to cure with good colors. The use of ample amounts of phosphates and potash appears to be essential for maturation of the leaf, and these elements also serve to reduce or prevent damage from leafspot-producing mico-organisms.

Making of rows

After the soil has been brought into suitable tilth and the fertilizer has been incorporated, the next procedure is to mark or place the rows. In the Near East a hoe is generally used to make shallow furrows. In the Marmara Sea region the rows are spaced 50 cm. (20 inches) apart. In the Black Sea region the spacing interval varies greatly but 35 to 40 cm. is the usual distance. At the tobacco substation near Samsun the optimum spacing of rows was determined by experimentation to be 40 cm. A spacing of 25 cm. for growing Basma in Macedonia is not unusual. In Rhodesia the furrows are made 18 to 24 inches apart and in the Union of South Africa 30 to 36 inches apart. In the southeastern United States the rows are placed 20 inches apart by use of a 10-inch wide single-shovel plow. A little soil rolls into the adjacent furrow when such a plow is used to open the furrows. A field prepared in this manner becomes a series of parallel ridges 20 inches from crest to crest. Closer spacing has been found to be impractical since it does not allow adequate space for cultivation and harvesting. Surface irrigation is facilitated by having the rows at least 30 to 36 inches apart but with such spacing they may plant paired or double rows.

Transplanting

Where the seedlings are five to six inches tall they are of sufficient size for transplanting. Throughout the Near East the young plants are

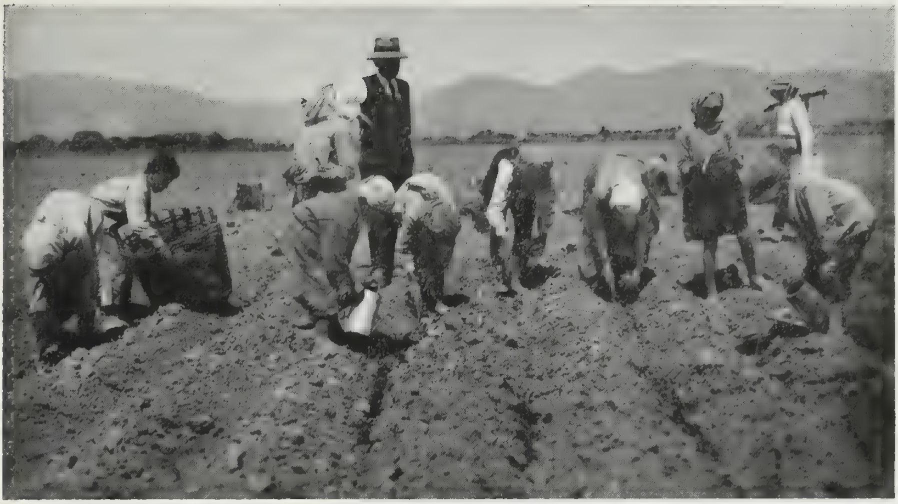


FIG. 49. Transplanting tobacco, in Turkey, in the bottoms of furrows. The seedlings are contained in the large basket, at the left. Holes are opened with a wooden peg, and each seedling is immediately irrigated by pouring water into a hole made beside the transplant. Water is being carried in two large cans supported on a rack on the shoulders of the man in the background, at the right. Two persons are irrigating and four are planting. Courtesy C. B. Spivey.

set in the furrows in holes made by the use of a wooden peg. Then another hole is made alongside each plant to press the soil around the roots and the base of the stem. These holes are left open to receive water applied with a sprinkling can immediately after setting each plant. If the plants in 20-inch rows are spaced four inches apart in the drill there will be approximately 80,000 per acre, 4.5 inches apart, 70,000 per acre, and five inches apart, 60,000 per acre.

Also in the Western Province, Union of South Africa, the plants are set in furrows, allowing eight- to nine-inch spacing in the drill. In the southeastern United States many growers prefer to mark the rows with a bull-tongue plow and then set the plants on the level, at intervals of four to five inches. Others prefer to set the plants on the side of the ridge near the mid-point from the bottom to the top of the ridge.

Hand transplanters that release the plant and water simultaneously constitute very satisfactory equipment for transplanting. One person operates the transplanter and another one drops the plants singly into the machine. It is not necessary to replant when such a machine is used unless the weather is very hot and the soil is quite dry at time of transplanting. Such transplanters cannot be used, however, when the soil is wet. Under such conditions growers use a wooden peg to make holes into which the seedlings are set and then to press the soil around the set plants.

Slow-speed tractor-drawn machines have been devised that plant either single rows or else two or four rows simultaneously. For their use the surface of the field to be planted should be carefully leveled. The machine opens furrows into which the plants are to be set, waters each one, and firms the soil alongside. Satisfactory survival of transplants has resulted from use of these machines, especially when the soil is well prepared in advance of transplanting and the seedlings are exposed to full sunshine for several days prior to removal from the seedbed.

One should transplant aromatic tobacco as soon as danger of frost is past. Crops planted early seldom fail to be superior to those planted later in the season. Proper spacing is all important because quality of cured leaf is directly related to leaf size. Leaf size is kept small by close spacing. Moreover both quantity and quality of aroma and chemical composition in a given variety are directly related to size of leaf. The matter of spacing as a factor in modifying the quality of the crop will be considered subsequently in Chapter IX.

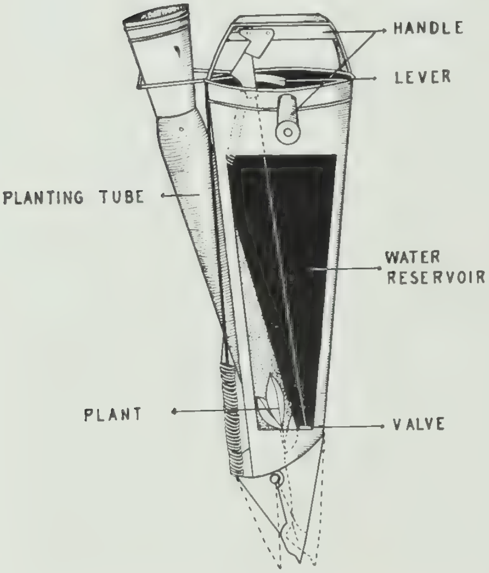


FIG. 50. Hand transplanter. Each seedling may be transplanted and watered simultaneously. One person operates the transplanter and another drops the seedlings into the appliance.

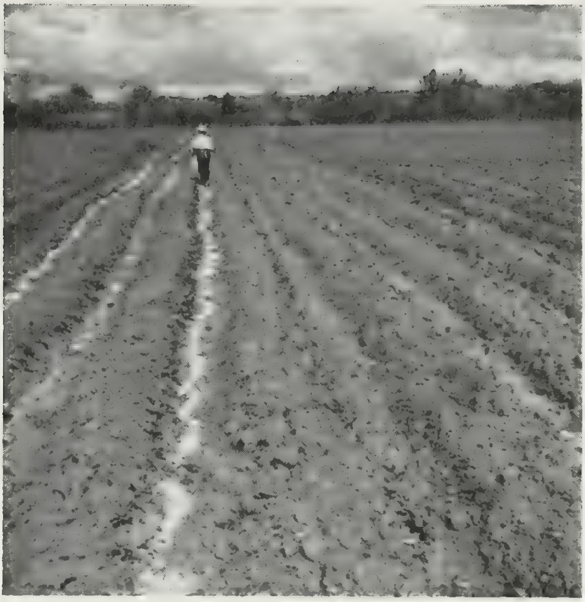


FIG. 51. Transplanting in single rows, in Venezuela, along the sides of ridges. Furrow irrigation provides the necessary water. Courtesy Gene L. Warren.

Cultivation

By nature, plants of oriental varieties of tobacco are more hardy than are those of flue-cured varieties or Burley varieties. For this reason they become established quickly after being transplanted, and the first cultivation is usually made about two weeks after transplanting. This first cultivation is made by use of a hoe or hoe-fork. A V-shaped hoe facilitates removal of weeds and loosening of the soil between closely spaced plants. If the plants are set on the sides of ridges, a hoe-fork

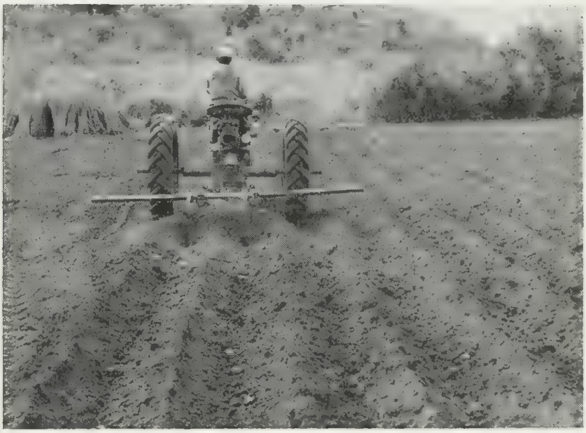


FIG. 52. Preparing a field in Venezuela for transplanting in double rows by use of tractor-drawn, double-shoveled plows. Courtesy Gene L. Warren.

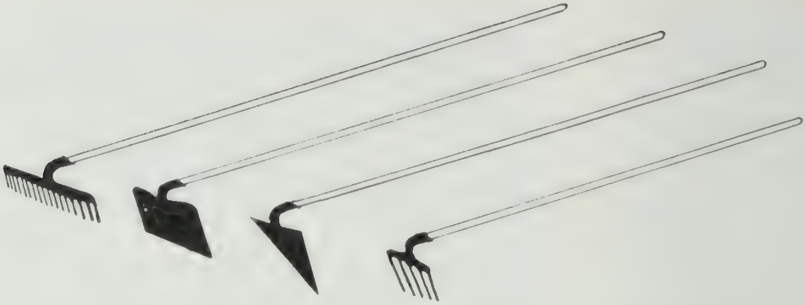


FIG. 53. A rake, two kinds of hoes, and a hoe-fork, tools used for hand cultivation.

serves best to rake the crest of the ridge into the furrow of the adjacent row, thus leaving the soil surface level. In the Near East all the cultivations are made by use of a short-handled hoe.

Cultivators drawn by a horse or mule may be used for the second cultivation. Such cultivators are equipped with three narrow bull-tongue shovels or else a small double shovel. They can be used only if the spacing interval between rows is at least twenty inches. The soil should be loosened thoroughly with this second cultivation, all the weeds should be killed, and a low ridge or hill should be made alongside each row. It may be necessary if the cultivator fails to accomplish these purposes to use a hoe to finish the cutivation.

During normal seasons further cultivation will not be required. By this time the plants will have grown sufficiently to shade the soil and thus check appreciable growth of weeds. However, the type of weather that

Diagram of field and plants before first cultivation

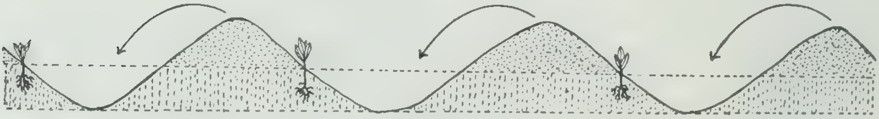


Diagram of field and plants after first cultivation

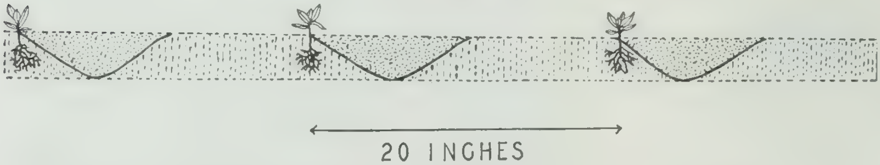


FIG. 54. Diagrams showing seedlings planted alongside of the ridges and the leveling of the field by the first cultivation.

prevails and the growth of weeds may make necessary another cultivation. If the soil surface becomes encrusted moisture can be conserved by shallow cultivation. Sometimes the plants make slow growth during the early part of the growing season because of prevailing dry weather. Under these conditions shallow cultivation to make a dust mulch is beneficial. But under no circumstances should the grower apply extra fertilizer to make the plants grow faster. If extra fertilizer is applied and rains occur, the plants will grow too rapidly. The leaf produced on rapidly grown plants is thin, papery, and almost completely lacking in quality. If it has any value in cigarette manufacture it may serve only as filler. It is well established that good quality leaf of oriental tobacco results only when the rate of plant growth is slow and uniform throughout the entire period of development after transplanting.

Incekara (1958) states that during periods of drought in the region bordering the Aegean Sea some growers are obliged to irrigate their tobacco fields one or more times. Such is the case too in Venezuela, where the crop must be grown during the dry season. Great care must be exercised, however, when irrigation is used, because crops given excessive amounts of water are of inferior quality, the cured leaves being thin, chaffy, and lacking in body and aroma.

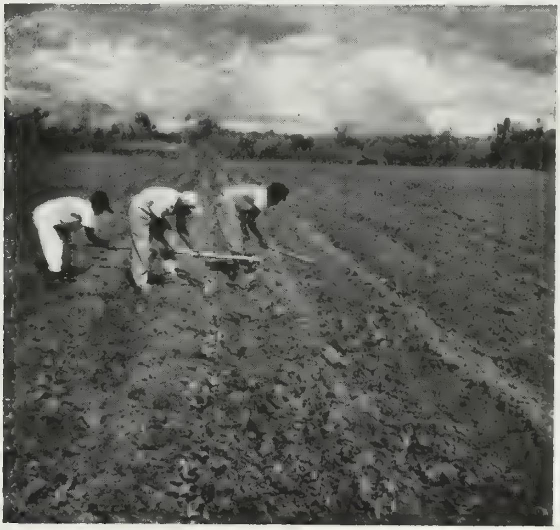


FIG. 55. First cultivation by use of hoes in Venezuela. Irrigation furrows between the rows remain intact. Courtesy Gene L. Warren.

Harvesting

Proper harvesting and curing are possible only when provision has been made in advance for essential equipment. This equipment includes curing barns, curing racks, baskets, boxes, shelters for stringing and wilting, needles, string, laths, wires, press boxes, twine, burlap, etc. Different equipment, determined by harvesting and curing methods, is used in different countries.

The leaves should be harvested as they mature, a few at a time, beginning with the lowermost ones. This method of harvesting is known as the priming method. The time for making the first priming is determined mainly by the weather that prevails during the growing season. Usually it is made about thirty days after transplanting. Oriental tobaccos are seldom if ever topped for the reason that the upper leaves of topped plants are adversely modified in size, texture, and chemical composition. Data to support this assertion, however, are meager. Piescu and Dimofte (1936) compared topped and non-topped Molovata tobacco, grown at different spacings. Their trials extended over three seasons with the average results as summarized in Table XXII.

It becomes difficult to interpret the data in Table XXII partly for the reason that the analyses do not show the comparative composition of the individual primings. It is shown however that the content of nicotine and carbohydrates is increased as a consequence of topping.

Great care must be exercised to harvest leaves at the proper stage of maturity. The grower must learn from actual experience with a given variety when the leaves are mature. Some varieties of aromatic tobacco are much greener; i.e., they contain more chlorophyll than do

TABLE XXII. EFFECT OF TOPPING AND SPACING ON THE COMPOSITION OF LEAVES OF THE VARIETY MOLOVATA *(percentage of dry weight)*

Spacing interval, cm.	*Total nitrogen*		*Nicotine*		*Total carbohydrates*	
	not topped	*topped*	*not topped*	*topped*	*not topped*	*topped*
30 x 10	1.35	1.53	0.46	0.53	14.23	15.48
30 x 15	1.64	1.59	0.49	0.59	14.32	13.13
40 x 20	1.89	1.90	0.47	0.71	11.01	9.35
50 x 25	2.05	1.93	0.60	0.96	9.01	8.89
60 x 30	2.05	2.25	0.93	1.38	7.51	6.32
70 x 35	2.43	2.37	0.82	1.36	2.31	2.36
80 x 40	2.40	2.56	0.99	1.47	2.59	2.28

FIG. 56. Sketch of a single-row cultivator of a kind that may be used for the second cultivation, and for subsequent ones.

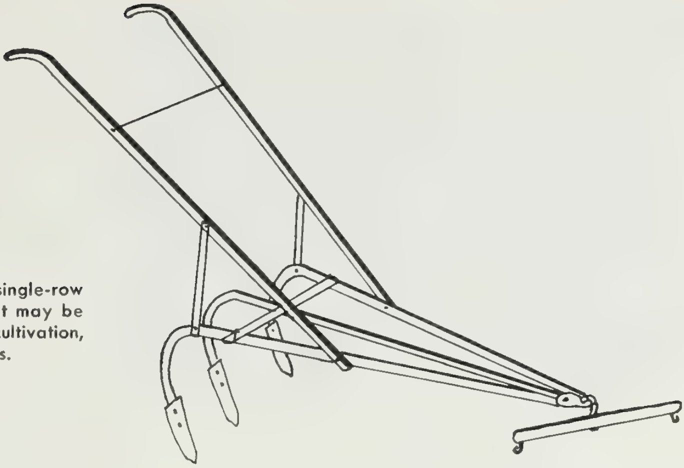


FIG. 57. Single-row cultivator that is being ox-drawn, in Venezuela. Courtesy Gene L. Warren.

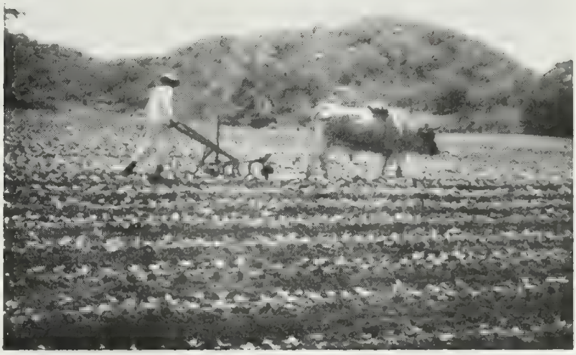


FIG. 58. Tobacco field near Brusa, Turkey. The ditches separate fields belonging to different growers.

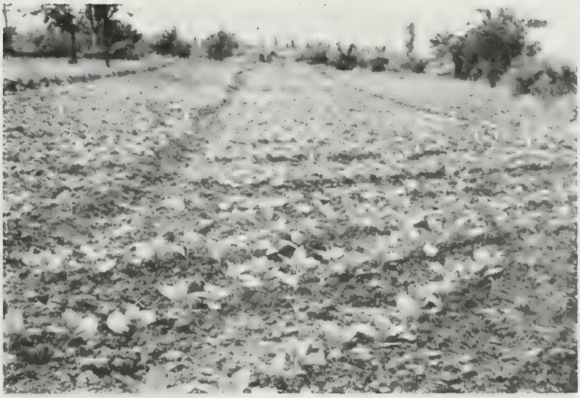


FIG. 59. Large field of Izmir tobacco in the Aegean region, Akhisar, Turkey.

other varieties. Wolf and Wolf (1955) found that mature leaves of Xanthi-Yaka have 1.66 mg./gm. of chlorophyll on a green weight basis whereas Stanimaka has 0.94 mg./gm., a comparative ratio of 1.76:1.

If the leaves are too green when primed they will be greenish in color when cured and thus be undesirable. If they are overmature, the cured leaves will lack body, will shatter when handled, and will have a dull dry color. Leaf maturity is indicated by a slight change from the normal green color toward yellow, together with an amount of pliability that permits the leaf to be folded gently in the hand without breakage.

Normally five to eight primings must be made to harvest a crop; three to five leaves called a hand are collected at each priming. Many growers discard the lowermost two or three leaves. Such leaves when cured are essentially neutral and contribute little besides being a filling

FIG. 60. Field of Samsun tobacco near a village in the Black Sea region.

material. Every effort should be made to harvest successive primings as soon as the leaves are mature. If the grower fails in this operation there will be loss both in weight and quality of cured tobacco.

Harvesting should be postponed for a day or two after heavy rains. The secretion of gums and resins by the glandular hairs are washed away by rains and will be replaced rapidly during a few sunny hours. The best time to prime aromatic tobacco is in early morning, before the dew has evaporated. At this time of day the leaves are turgid and can be removed without injury to the stalk. During midday, on hot, sunny days the leaves may be wilted. If primed then they stick together badly, bruise easily, and are more difficult to string or otherwise to handle. Bruised leaves, when cured, are greatly reduced in quality.

In harvesting, the best procedure is to hold the plant with one hand and with the thumb of the other placed above the base of the leaf to be removed and the first two fingers placed below, remove the leaf with downward pressure. If four leaves are to constitute the hand, remove the one uppermost first and pass in succession to those below.

FIG. 61. Field of aromatic tobacco being grown near Oxford, N. C.

After a little experience one can become very adept at removing each hand of leaves. In the Near East the leaves are placed properly in a special basket (*küfe*), if they are piled in order, the tips (*kuyruk*) toward the center and the butts (*bach*) toward the outside. These baskets measure approximately 3 × 2 × 2 feet; two such basketfuls of leaves, when suspended one on each side, astride a burro, are taken to the stringing shed or other shade (*salash*), where the leaves are threaded. All leaves must be threaded on the same day in which they are primed for the reason that they will heat and discolor if left in a pile. In stringing, a long needle is passed through the midrib of the leaf about half an inch from the base. When the needle is filled with leaves they are slipped off the needle onto a cord or cotton string.

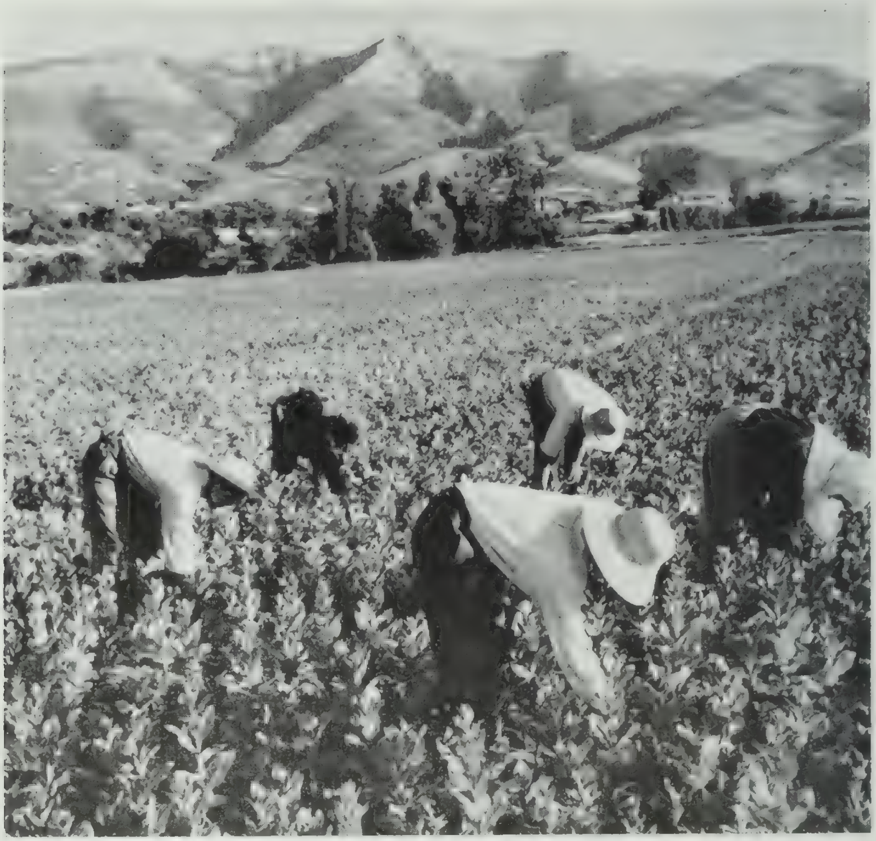


FIG. 62. Harvesting scene in Macedonian region of Greece in which lowermost leaves are remove and usually left on the ground. Courtesy D. Arghyroudis.

This process is repeated until the string is sufficiently filled with leaves. The string of leaves is then fastened at the ends to a lath or light pole. Next the leaves are spread or uniformly spaced along the string to permit air to circulate freely among them. Unless this is done moisture will condense on the leaves and they may become pole-burned. Once the leaves have been spread, the strings are fastened at intervals to prevent sagging. In this condition the strung leaves are ready to be "yellowed" and wilted.

Another method of stringing that is much less time-consuming is rapidly coming into favor in the southeastern United States. This method makes use of 10-gauge wires instead of strings. Threading onto wires may be done most economically in the field. The hands of leaves, immediately after removal from the plants, are placed onto the wires. A special wooden rack, holding the wires to be filled, together with a supply of empty wires, is moved along the row at the convenience of the one harvesting the leaves. The leaves on the wires are promptly gathered and placed in the shade in boxes until they can be conveyed to the wilting shed.

Yellowing and wilting

The quality of the final product greatly depends upon proper yellowing and wilting. After the leaves have been strung and attached to laths or placed on wire holders they are hung on racks in a wilting room, so that the tobacco can become yellow and wilt. This room should be relatively cool (70° to 80°F.), and should be protected

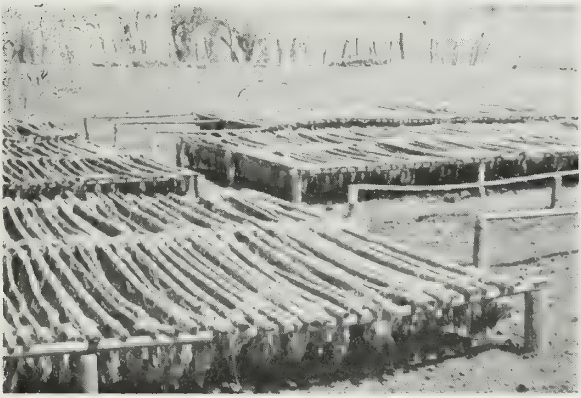


FIG. 63. Sun-curing of aromatic tobacco leaves that have been attached to bamboo sticks and suspended on racks, in Venezuela. Courtesy Gene L. Warren.

against air currents. The relative humidity should be maintained at 85% or above. Successful wilting and yellowing requires thirty-six to seventy-two hours, depending upon the temperature, relative humidity, variety of tobacco, stage of maturity of the leaf, and number of the priming.

For leaves of average size attached to laths, the laths should be spaced about three inches apart. For tobacco on wires, the wires should be attached one above the other to the vertical supports so that the leaves on neighboring wires almost touch one another. If leaves are hung too closely in the wilting shed, water lost by the leaves will accumulate on them in droplets and cause damage. Free access of air must be provided at all times to insure proper yellowing and wilting, but ventilation must be controlled. During periods of extremely dry weather it may be necessary to provide additional moisture by spreading a layer of moist sawdust over the floor or by sprinkling the floor with water. If the tobacco is exposed to conditions of rapid drying the color of the cured leaf remains green.

Layton (1952) found during wilting and yellowing of Smyrna, Samsun, and Kavala varieties that the rate of water loss is slow and the percentage loss ranges from 5% to 10% within a period of approximately forty-eight hours.

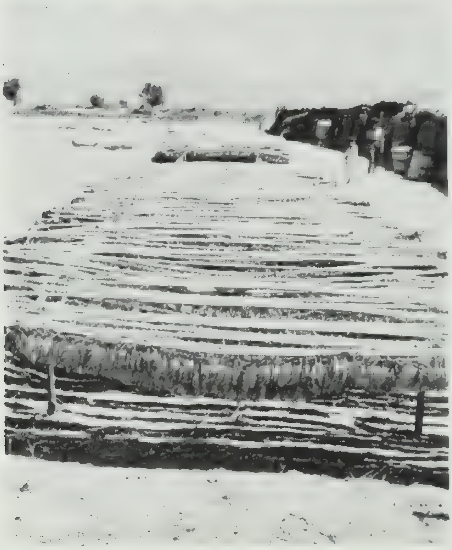


FIG. 64. Sun-curing of Izmir tobacco on racks near Ephesus (Efes), Turkey. Note the workers' huts at the right.

Further curing

After the primed leaves have become yellow and wilted they are ready for further curing by either of two methods. They may be placed on racks or trellises or else may be transferred to a curing barn.

Throughout the Near East the leaves, after being strung, are attached to sticks eight to ten feet long, and are left under cover during the night. On the following morning the sticks bearing the leaves are placed on a trellis (*küman dalla*) made of two rows of posts with wires fastened along the tops of each row. The distance between rows of posts is determined by the length of the sticks. Frames with strings of tobacco attached that can be moved along wooden trellises are also used for the same purpose. The leaves are protected for a day or two against too rapid loss of water by being covered with burlap. During this period the leaves wilt and become yellow. Then they are exposed to sunlight for a day or two, after which the sticks, bearing leaves, may be placed on the ground, exposing first one side and then the other to direct sunlight. To produce a final product in which lemon

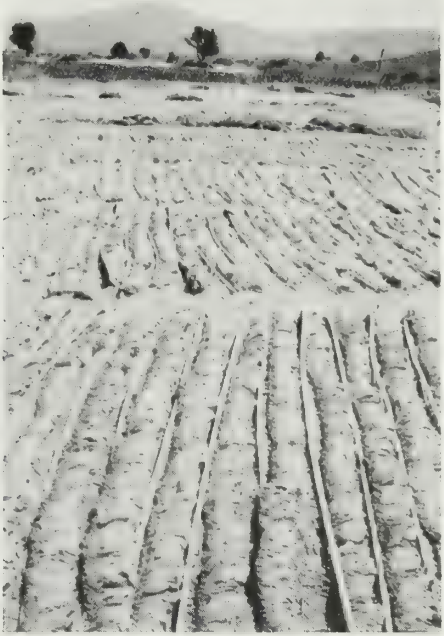


FIG. 65. Strings of Izmir tobacco attached to reeds, which are placed on the ground during the final stage of sun-curing, near Ephesus, Turkey.

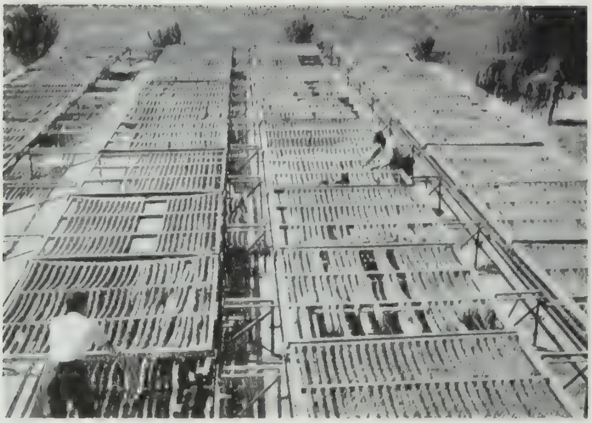


FIG. 66. Racks of tobacco in the Macedonian region of Bulgaria. Courtesy *Tobacco*, 1958.

to orange colors predominate it is necessary to give more attention than is the custom throughout the Near East to control of relative humidity during the first 48-hour period after harvesting the leaves. To do this would require that the strings of leaves be kept in a wilting shed. Also it might be advantageous to protect the leaves from contact with the soil in the final stages of curing by spreading straw over the ground and placing the leaves upon the layer of straw.

After the leaves are dry the sticks and attached strings of leaves are piled under a burlap cover. When the pile contains enough tobacco for a truckload, it is hauled to a magazine (*mazhen*) or storage, the sticks are removed, and the strings of tobacco are left piled. Soon after harvesting is completed the piled tobacco is moistened to bring it into order and it is then made into *kaloup* bales. Once baled it is

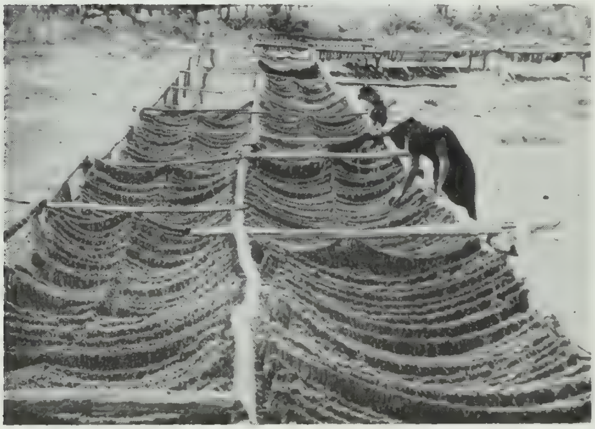


FIG. 67. Festoons of aromatic tobacco on drying racks in Venezuela. Courtesy Gene L. Warren.

ready for examination by buyers and to be transported to the storage centers for manipulation.

In southern Africa, where seven-foot-long sticks are used to support the threaded leaves, the sticks are placed about four to six inches apart on trellises, but are covered with a thin fabric to prevent the leaves from becoming scorched at least during the early stages of curing. These trellises have a ridgepole that supports a canvas cover that is spread over the leaves at night to protect them against dew. The leaves should be dried until 70% to 80% of the water content is lost. At this stage the leaf blades are dry and the midribs are partly dry. The leaves left on the sticks may then be bulked in a pile in a cool, dry room, or the sticks may be closely packed, with the leaves hanging.

Some growers contend that there is virtue in exposing aromatic tobacco to direct sunlight during the current process. Experience in the southeastern United States has shown, however, that such exposure may bleach the colors and that leaves with livelier, brighter colors are secured if they are cured in barns and are never exposed to direct sunlight. Temperature rather than sunlight operates in the curing of air-cured leaf. An increase in air temperature of 10°C. increases the rate of water loss twenty-five times. Moreover, increase in temperature decreases the relative humidity and thus hastens drying.

In recent years, in Bulgaria, similar experiments have been conducted with use of curing barns. Dimitrov and Galev (1958) measured the effects of increased temperature, decreased relative humidity, and circulation of air in curing of threaded leaves hung in barns.

Several investigators have been concerned with the chemical changes

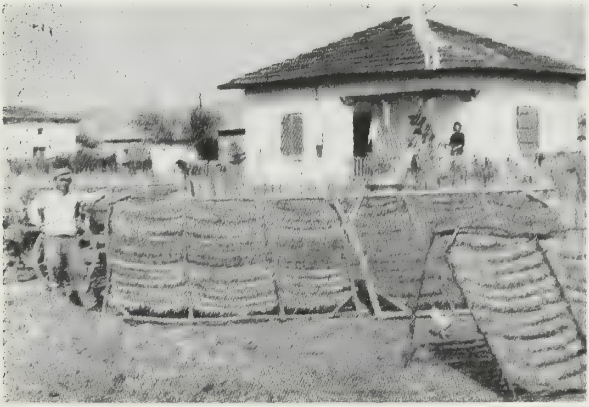


FIG. 68. Tobacco on movable racks being sun-cured near Drama, Greece. Courtesy *Tobacco*, Jan. 1960.

that occur during the curing process. Layton (1952) using three varieties of tobacco, Smyrna, Samsun, and Kavala, found that within three to five days after yellowing and wilting the water content is reduced to approximately 50% of that of freshly harvested leaves. During this period starch is hydrolyzed, and seven to eight days after harvest a minimum range of 3% to 4% remains. The sugars increase concomitantly but then are lost rapidly by respiration throughout a period of seven to ten days. During the curing process the ratio of soluble to insoluble nitrogen increases markedly.

Andreadis and Toole (1939) traced the changes that occur in curing, in nicotine content as related to stalk position of the leaf in Basma Adriani, throughout two growing seasons, 1934 and 1935, with the results shown in Table XXIII.

During 1934 the nicotine content increased approximately 25% during curing but there was no appreciable increase in 1935, if the data are employed to show changes for all of the leaves as a unit.

When aromatic tobaccos are cured in barns, it is essential that specially constructed barns, provided with oil furnaces, be used. Plans

TABLE XXIII. NICOTINE CONTENT OF FRESH AND CURED LEAVES *(percentage of dry weight)*

Leaf number	*1934 crop*		*Leaf number*	*1935 crop*	
	fresh	*dry*		*fresh*	*dry*
1	0.77	1.19	1	0.79	0.54
2	0.88	1.10	2	0.78	0.60
3	1.07	1.55	3	0.84	0.76
4	0.89	1.58	4	0.81	1.21
5	1.26	1.53	5	0.71	0.74
6	1.25	1.73	6	1.34	1.46
7	1.05	1.61	7	1.15	1.32
8	1.19	1.45	8	1.57	1.35
9	1.03	1.87	9	1.68	1.67
10	0.84	1.66	10	1.34	1.55
11	1.49	1.74	11	2.05	1.52
12	1.28	1.52	12	1.73	1.38
13	1.25	1.44	13	1.58	1.27
14	1.26	1.60	14	1.41	1.60
15	1.16	1.39	15	1.30	1.32
16	1.33	1.52			
17	1.31	1.71	16-17	1.42	1.47
18-19	0.99	1.53	18-20	1.34	1.54
20-21	1.17	1.68	21-24	1.19	1.55
22-24	1.14	1.77	25-30	1.21	1.58
25-28	1.18	1.85			
29-37	1.18	2.06			
Av.	1.13	1.59	Av.	1.27	1.28

for construction of such barns will be given at another point. Since rainy weather may occur during harvest, extended periods of high relative humidity may prevail, a condition very unfavorable for curing. During such weather the leaves become moldy, resulting in decline in quality or even rendering much of the crop worthless. When barns are used, the leaves are strung on wires attached to wooden sticks suspended from an overhead frame. The wires are spaced to allow about an inch between the leaf tips of those on the upper wire to the leaf bases of those on the wire immediately below. Such spacings will aid in ventilation.

In the southeastern United States properly constructed, heated, ventilated barns make it possible to effect good curings, regardless of the weather, and to prevent losses from moldiness. Such barns have thermostatically controlled oil furnaces with circulators that force the air through ducts. The heated air passes downward among the leaves and is discharged to the outside through vents near the base of the barn. At no time should maximum temperature exceed 100°F. to 105°F. in order to prevent excessive volatilization of aromatic substances. During the first two or three days of curing the air-intake opening on the furnace should remain wide open. By the end of three days sufficient moisture will have been lost by the leaves so that the air-intake may be closed one-half or more. A relative humidity of 50° to 65°

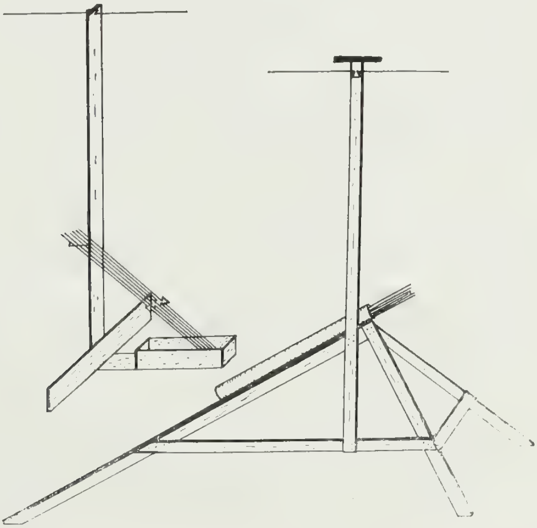


FIG. 69. Racks to hold wires for threading the leaves immediately after priming them. The operator moves the rack along as he primes.

provides good conditions for curing. During prolonged rainy periods it may be necessary to exhaust a portion of the heated air to maintain the desired relative humidity. During hot, dry weather it may be necessary to prevent too rapid loss of water from the curing leaves by spreading sawdust on the floor and wetting the sawdust. On the other hand, the relative humidity of the air outside the barn may be such that the heat can be turned off and the doors and ventilators opened wide. Movement of air is essential to effect the curing process, even when the barn is wide open. Hence if wind is not blowing, the circulator fans should be allowed to run.

As to the length of time required to cure tobacco by use of a curing barn, experience shows that the period ranges from seven to ten days. The factors involved depend upon prevailing weather, the number of the priming, upper leaves requiring more time than lower ones, and the care exercised in providing proper heat and ventilation. A high quality product can be secured even when two primings are being cured in the same barn at the same time if the relative humidity is controlled within the range 50% to 65%. Proper use of a curing barn requires that instructions given by the manufacturer for operating the furnace must be followed implicitly. These instructions indicate how to set the thermostat for cloudy or rainy days, and at nighttime. They also state how to regulate the ventilators. The furnace may be turned off on sunny days and the doors opened to permit natural ventilation. To determine temperature and humidity it is necessary to have reliable thermometers and hygrometers.

From the foregoing account it should be apparent that curing is not simply a drying of the leaves. It is a vital or living process that begins with yellowing and wilting. The cells of the leaf remain alive and continue to respire and to undergo other oxidative changes as water is being lost gradually. Eventually the cells are deprived of moisture to the extent that they die, but due to action of enzymes chemical changes continue to occur until the leaves are air dry. They are then said to be cured. However, enzyme-induced changes may continue to take place at a very slow rate, and such changes in air-dried leaves constitute what is known as aging or fermenting.

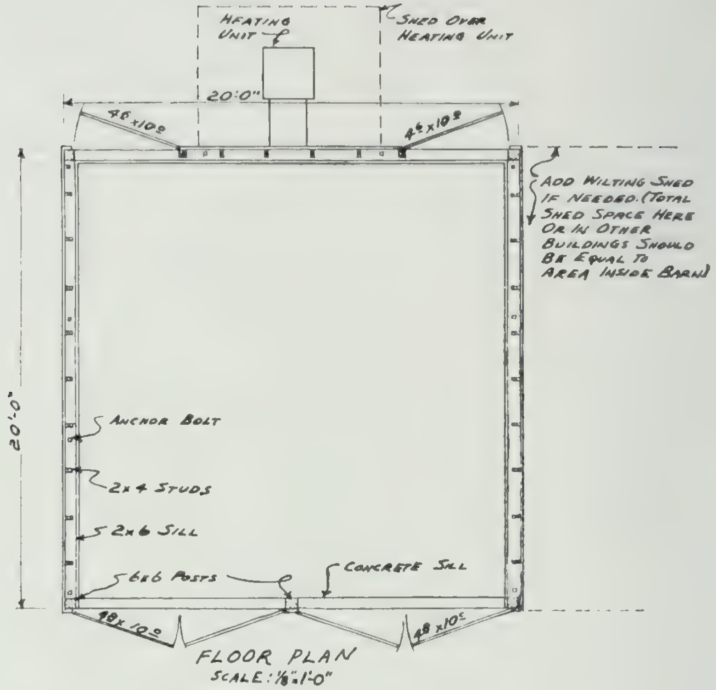
The curing barn

In the southeastern United States, where rains usually occur at frequent intervals throughout the curing season, it is essential that the grower of aromatic tobacco should provide himself with an artificially heated curing barn. Failure to do so will mean losses from decay among part or all of the primings should rainy weather prevail. It is the universal experience of all who have attempted to produce this type of tobacco that careful attention should be given during each stage of curing to control of relative humidity of the ambient air. It is not only possible to prevent losses from decay by use of a heated curing barn, but the cured product will be brighter and more uniformly colored. The curing leaves may never need to be exposed to direct sunshine. But on sunny days the doors can be opened to permit the dry air to circulate freely throughout the barn. By so doing, the labor of moving the tobacco out into the sunshine and then returning it to the barn is avoided. Wetting from sudden showers is thus avoided. As is well known, quality of the cured leaf is markedly decreased if rain or dew falls on the harvested tobacco during curing.

To date much effort has been expended on planning, constructing, and operating a satisfactory type of curing barn. As a result, matters of building materials to use, cost of construction, and method and cost of operation have been determined. Specifications for a barn of sufficient size to cure a crop produced on two acres are given. These specifications include materials needed for constructing a barn 14 feet long, 10 feet wide, and 10 feet high, having a concrete floor and metal roof and sides. One end of the barn can be completely opened, and the other end has two doors. The heating unit with circulator is installed at the end having two doors. The heated air is introduced through a duct above the tobacco. The tobacco is strung on wires that are clamped on wooden strips suspended from beams that cross the ceiling.

Bulking and baling by growers

Whether the crop is sun-cured or cured in a barn, it should be bulked and stored for a time in a weather-tight packing house prior to being baled. Proper storages should have doors and windows at opposite sides to provide for circulation of air. If the storage is damp the cured tobacco may become moldy. Moldy tobacco is quite worthless. If the cured leaf is left on the sticks or wires, the sticks may be closely hung or the wires may be arranged in small piles. In whatever



BILL OF MATERIALS

CONCRETE, MASONRY:
2 CU. YD. CONCRETE, 1:2¾:4 MIX
OR: 10 BAGS CEMENT
1.2 CU. YD. SAND
1.6 CU. YD. STONE
88 - 8x8x16 BLOCK
2 BAGS MORTAR CEMENT
0.3 CU. YD. MORTAR SAND

LUMBER:
5 PCS 6x6x10' (POSTS)
22 " 2x6x12' (RAFTERS, ETC.)
24 " 2x6x10' (SILL, TIES)
3 " 2x6x10' (DOOR JAMBS)
9 " 2x4x14' (PLATE)
44 " 2x4x10' (STUDS, BRACES)
4 " 2x4x12' (ROOF TRIM)
650 BD. FT. WALL SHEATHING
650 " " ROOF SHEATHING
350 " " T&G FOR DOORS
450 LIN. FT. 1x2 BATTEN STRIPS

ROOFING: 5½ SQUARES
SIDING: 5½ SQUARES
HINGES, ANCHOR BOLTS, NAILS, ETC.

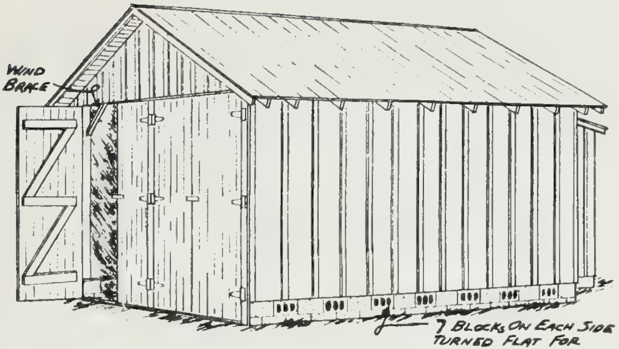
NOTE: ABOVE LIST DOES NOT INCLUDE MATERIALS FOR HEATING UNIT SHED AND WILTING SHED.

HEATING UNIT SPECIFICATIONS

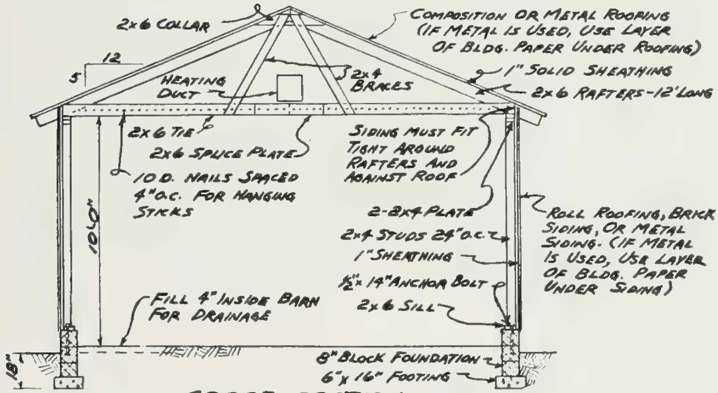
HEAT CAPACITY - 150,000 BTU/HR.
FAN CAPACITY - 3,000 CFM
THERMOSTAT CONTROL FOR TEMPERATURE SETTINGS TO 105°F.
FAN SHOULD BE CONNECTED FOR CONTINUOUS OPERATION.
BUILDING MUST BE REASONABLY AIRTIGHT FOR SATISFACTORY RESULTS WITH AIR INTRODUCED AT TOP OF BUILDING.

FIG. 70. Floor plan and bill of materials for construction of barn. Courtesy N. C. State College Extension Service.

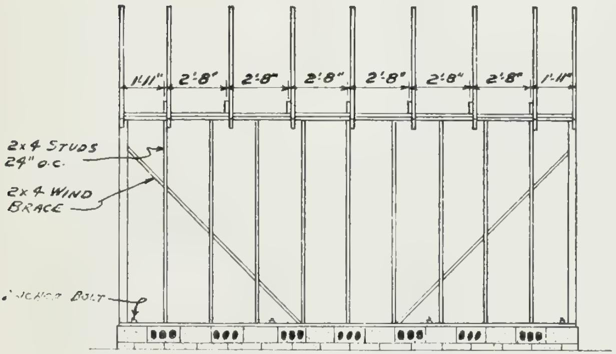
FIG. 71 (on facing page). Views of aromatic tobacco curing barn. Courtesy N. C. State College Extension Service.


WIND BRACE
7 BLOCKS ON EACH SIDE TURNED FLAT FOR VENTILATION

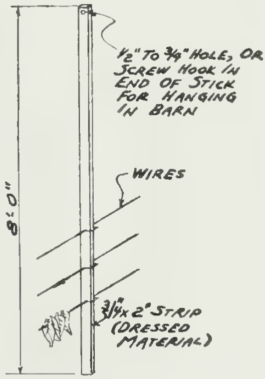
GENERAL VIEW
AROMATIC TOBACCO BARN


2x6 COLLAR
COMPOSITION OR METAL ROOFING (IF METAL IS USED, USE LAYER OF BLDG. PAPER UNDER ROOFING)
12
5
HEATING DUCT
2x4 BRACES
1" SOLID SHEATHING
2x6 RAFTERS-12' LONG
2x6 TIE
2x6 SPLICE PLATE
SIDING MUST FIT TIGHT AROUND RAFTERS AND AGAINST ROOF
10 D. NAILS SPACED 4" O.C. FOR HANGING STICKS
10'0"
2-2x4 PLATE
ROLL ROOFING, BRICK SIDING, OR METAL SIDING. (IF METAL IS USED, USE LAYER OF BLDG. PAPER UNDER SIDING)
2x4 STUDS 24" O.C.
1" SHEATHING
½"x 14" ANCHOR BOLT
FILL 4" INSIDE BARN FOR DRAINAGE
2x6 SILL
18"
8" BLOCK FOUNDATION
6"x 16" FOOTING

CROSS-SECTION
SCALE: ⅛"=1'0"



SIDE FRAMING DETAIL
SHOWING TRUSS SPACING FOR HANGING STICKS


½" TO ¾" HOLE, OR SCREW HOOK IN END OF STICK FOR HANGING IN BARN
8'0"
WIRES
¾"x 2" STRIP (DRESSED MATERIAL)

STICK FOR HANGING WIRES

manner the cured tobacco is bulked in the storage, the primings should be kept separate and eventually should be baled separately.

To bring the leaves into condition for baling it is necessary, as a first step, to allow them to absorb moisture. Their moisture content should be sufficient to permit handling without breakage. This can be done by making a bulk on a dry board floor, or better on a board platform, to allow the air to circulate freely around the entire bulk. The tobacco on strings, sticks, or wires should be arranged in layers to make a pile two or three feet high. It may be advisable to cover the bulk with a canvas cover.

As soon as the bulked tobacco has absorbed sufficient moisture so that it can be handled without breakage it is in condition to be baled. The purpose of baling is to provide a convenient package for the grower to market the tobaccos. Once baled, the tobacco is protected from excessive changes in moisture content and from physical damage. It is most essential that the moisture content of the tobacco not be excessive at time of baling or else it will become moldy; the bales must be stored in a dry place.

A specially constructed press is essential for making bales. This press is a rectangular box 12 inches wide, 28 inches long and 20 inches deep, without top or bottom. A special top is made slightly less than

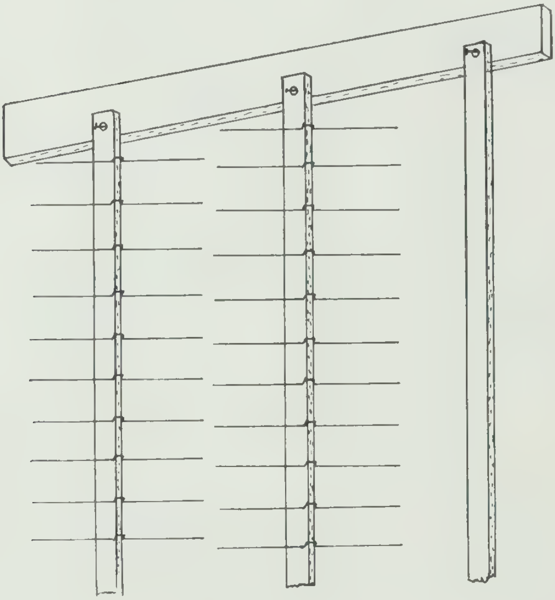


FIG. 72. Diagram of suspended boards to which the bent wires to hold the threaded leaves are clamped.

12 × 28 inches in dimensions, so that it can easily slide inside the press. The special bottom is somewhat larger than 12 × 28 inches. It is convenient to have a "super" to give added depth to the press, Fig. 73. If the leaves are small it is necessary to use an adjustable partition in order to make a narrow bale or one of any desired thickness. Then when the bale is placed for examination by the buyer on a curved-top table it is easy to remove leaves to determine their quality without untying the bale.

Burlap may be used as a cover for the bales. To make the bale, the cover is spread over the special bottom with one end of the cover even with the end of the press box. The edges of the burlap cover are folded so that the edges of the press will catch and hold it down. The free end of the strip of burlap is left hanging over one end of the box. The strip can afterwards be cut off to the length necessary to cover the top of the finished bale. The tobacco may next be placed in the press box by stripping the leaves off the wires, keeping them in rows with butts of the leaves toward the outside or, if threaded on strings, arranging the strings of leaves to make a *kaloup* bale. Fill the press box, and the super as completely as can be done by pressing the leaves down with the hands. This should require about twenty-five pounds of tobacco. Then place the top cover in position and press the cover

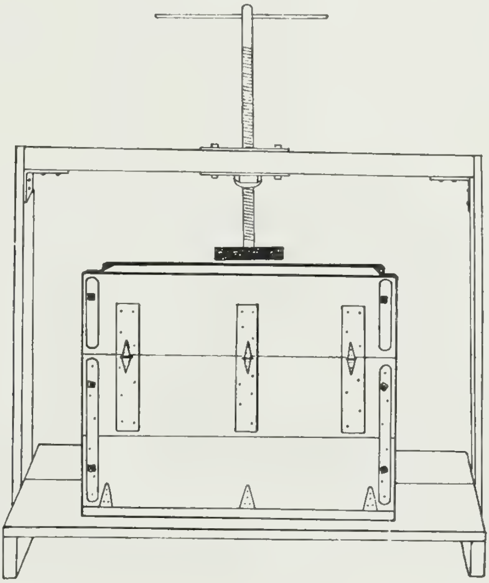


FIG. 73. Diagram of homemade collapsible wooden press for making bales.

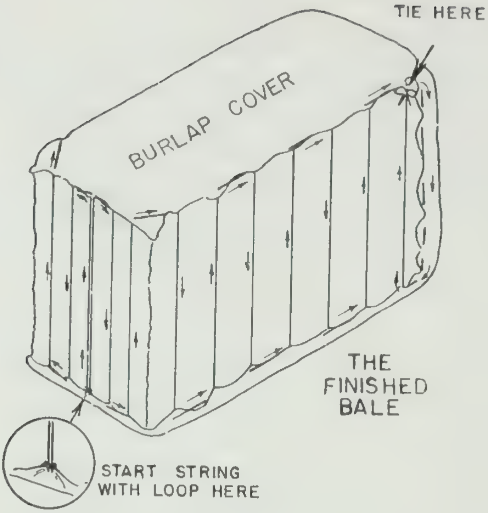


FIG. 74. Diagram of a finished bale with burlap cover sewed onto the bottom, one end, and the top.

down. It should then be possible to remove the super. The loose end of the burlap cover may then be pulled gently to remove the wrinkles. The press box is next lifted up and in this way slipped off the bale, meantime holding the bale down by pressing on the special cover. The special cover may next be removed, and the burlap cover drawn over the top of the bale. On release of pressure the bale should expand. If it does not expand the tobacco is too moist to bale and will mold if baled. If the bale expands the baling may be finished by sewing on the burlap cover. But first one person should pull the cover tight and another should press against the covered end of the bale and help press down the top, pressing with the palms. The cover should be cut to just reach across the top of the bale. To sew the cover on a bale will require twelve to fifteen yards of cord. Double the cord and thread the closed end onto a short needle used to sew sacks. Pass the threaded needle through the burlap at the center of the bale and then pull the loose ends of the cord through the loop made by its closed end. Then thread the two loose ends onto the needle and pass them through the cover at the center of the cover at the top of the bale. Further stitching requires sewing the top and bottom together by passing one string to the right and the other to the left, Fig. 74. When the stitching is completed, tighten the strings to remove the slack uniformly, meanwhile pressing on the top of the bale. When finished the bale will be quite firm and reasonably flat on top.

It is highly desirable that an experienced person show the uninitiated grower of aromatic tobacco how to make a bale and how to determine if the tobacco is too moist or too dry to be baled. As a result of poor judgment in baling serious losses may be incurred either from moldiness or from breakage.

Storage by the grower

Once the tobacco has been baled it should be kept in a clean, dry storage preferably with a wooden floor, until it is marketed. The bales should be placed one bale deep with an uncovered side next to the floor. On the following day the bales should be turned over, the other exposed side being next to the floor. The bales should be turned over daily until both uncovered sides feel equally dry. Then the bales can be piled three deep with uncovered sides facing each other. After three or four days the bales should be repiled, bringing the bottom bale to the top and the top bale to the bottom. The position of bales in the piles should be changed every few days, until the tobacco is marketed.

Sizes of bales

Growers generally do not make bales of uniform size. Such is not the case, however, with manipulated bales since valuable space in the storage is conserved if all of the bales are of the same shape, size, and weight. Bales of Samsun, made by growers, have an approximate weight of 17 kilograms, of Brusa 22 kilograms, of Basma 60 kilograms, and of Katerni 40 kilograms. Manipulated bales of these varieties weigh 23 kilograms, 30 kilograms, and 33 kilograms, respectively; and those of Izmir weigh 40 kilograms.

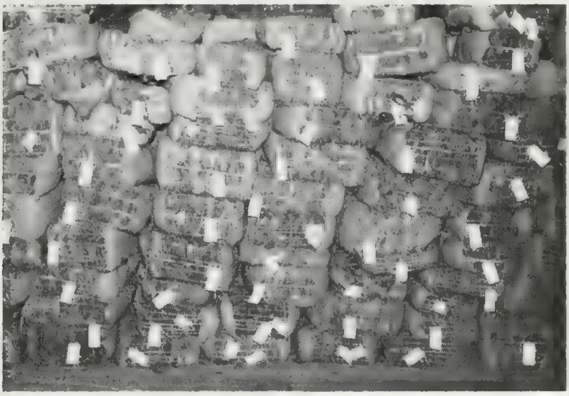


FIG. 75. Growers' bales piled up at a manipulation depot at Anderson, S. C.

In the southeastern United States growers' bales range in weight from 20 to 25 pounds and the manipulated bale weighs 70 pounds. Bales made by growers are flat for the reason that without loosening the cords it is possible to remove and to examine any bundle of leaves at time of sale. Such examination is facilitated by placing the bale on a table having a curved surface. As a rule in the Near East, the buyer, whether a merchant or an agent of a tobacco manufacturer or of the monopoly purchases the entire crop of an individual grower or of all the growers in a given village. At the time of purchase the weight and quality of each bale is recorded and the bales are appropriately marked. If for any reason the weight of the bale at delivery to the buyer does not agree with that recorded, the grower is held to be responsible and is liable to a severe fine, depending upon adjudication by a committee of three which represents the grower, the buyer, and a third disinterested person.

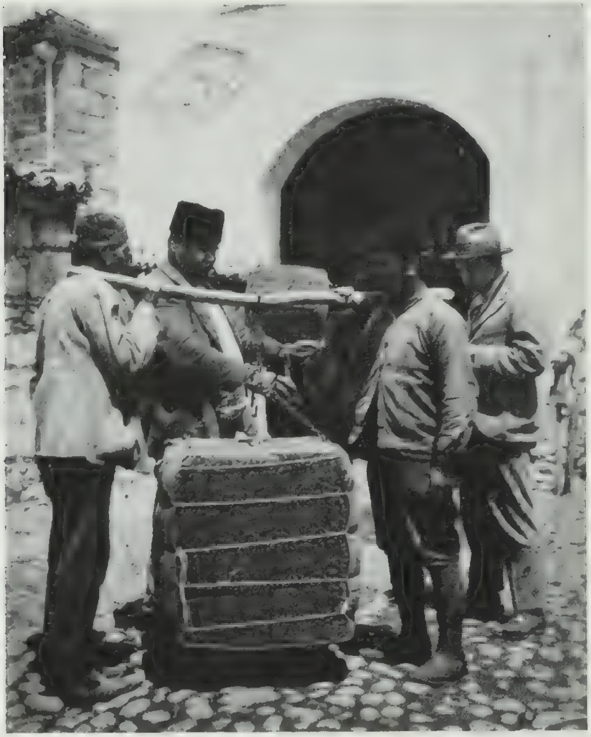


FIG. 76. Weighing a grower's bale at time of sale at Izmir, Turkey. Courtesy C. B. Spivey.

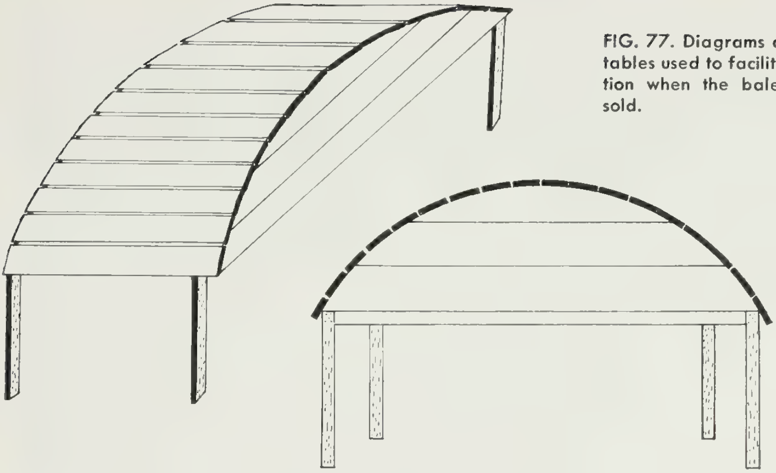


FIG. 77. Diagrams of curved-top tables used to facilitate examination when the bales are being sold.

Summary

Various aspects of the cultivation of aromatic tobaccos are discussed under such headings as seedbeds, their site, preparation of the soil, fertilization, seeding, care, and management; types of soils suitable for growing aromatic tobacco, field sites, preparation of the fields, fertilizer practices, transplanting, and cultivation. Harvesting, stringing, and curing methods are outlined. Finally procedures to employ in bulking, baling, and storing the cured tobaccos are described. This account is intended to provide growers with essential information to guide them in growing aromatic tobacco and preparing it for market.

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Chapter Eight

MANIPULATION OF AROMATIC TOBACCOS

The term manipulation as used in connection with aromatic tobaccos refers to three sequential processes, namely: grading, baling, and fermenting. The tobacco that is brought to the warehouses or storage depots in bales made by growers must be manipulated to prepare it for sale to the cigarette manufacturer and to improve its smoking qualities. Usually all of the tobacco in a given grower's bale is of the same priming. These bales are rather loosely packed, the leaves having been left on the strings on which they were cured; i.e., Kaloup bales. If the leaves are cured on wires, they are packed in layers after removal of the wires. In the discussion that follows consideration will be given in turn to each of these three manipulative practices.

Grading

Grading is the process of sorting the leaves into quality classes. The position on the stalk at which the leaf was borne is of primary importance in determining grade or quality. It is well known in the industry that quality tends to increase from the base of the stalk upward with each succeeding priming. No doubt this relationship of stalk position and quality was established from experience several hundred years before any technological evidence was available to confirm the relationship. In our early studies of this matter at Duke University it was found that the amount of ethanol extractive from mature leaves increases progressively with upward increase in position of the leaf, thus indicating a direct correlation between quantity of ethanol extractive and quality of the tobacco. As the result of chemical analyses made both here and in other countries it has been learned (see Chapter IX) that the leaves from different primings are strikingly different in composition. These chemical differences are related to leaf size and to imbalance in physiologic processes induced in the leaves left on the stalk. Such imbalance becomes increasingly greater as a consequence of removal of the mature leaves with each successive priming.

All available evidence shows that proper grading requires that each priming be kept separate. If the growing plants are uniform in age and size and the leaves are primed at the proper stage of maturity, the cured leaves of each priming will all be quite alike and will represent a major grade. Relatively few off-grade and defective leaves will need to be removed during sorting of any given priming when the crop is properly harvested and cured, if the "hands" have been kept separated. Each hand or priming has a different name. The terms employed in different countries, beginning with the lowermost priming, are as follows:

In Turkey, *dip alti, dip üstü, protomana, defteromana, tritomana, kovalama, ütch alti (uç),* and *ütch üstü;* in Macedonia *dip, orta, protomana, defteromana, tritomana, couvalama, outzalti,* and *outz;* in the U.S.S.R., there are either five basic hands; *dipsari, biringi, ortosar, anaci,* and *tepe* or else four classes; *dipsari, hazalama, anuci,* and *turuc;* in Rumania, *paolă, mijloc* 1, *mijloc* 2, *mijloc* 3, and *vârf;* in Bulgaria, *dip-orta* (lower two or three leaves having no commercial value), *biuk-ana* (grandmother), *ikindji-ana* (second mother), *uedkindji-ana* (third mother), *kovalama* (intermediate), *utsch alti* (lower tips), and *utsch uestu* (upper tips).

Several classes are customarily made in sorting each major grade, using as bases for separation such characteristics as leaf size, texture, color, aroma, and freedom from physical defects or damage. Each

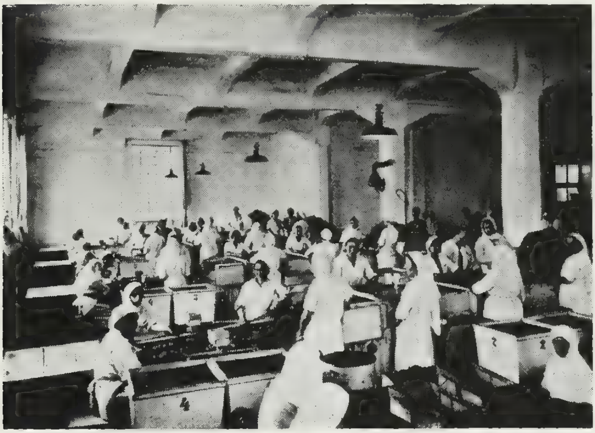


FIG. 78. Sorting or grading tobacco at a storage depot or magazine in Turkey. The leaves are first separated from each other by hand.

Near Eastern country has a somewhat different system, and there are also differences within a given country, depending upon the variety of tobacco being graded and the preference of the prospective buyer or market. Another important factor which is considered in grading is the site or locale in which the crop was grown. A given variety, for example, if grown in low-lying, level fields becomes *ova* (plains) tobacco, if on the slopes of hills or mountains *yaka* (collar of the hill), and if near the summit *djebel* (crest or top) tobacco. Best quality leaf of the Basma variety, for example, from each of these topographic sites becomes Basma Ova, Basma Yaka, or Basma Djebel, respectively. In addition, numbers or letters may be used further to subdivide each of these classes or groups.

Baling

Once the leaves have been sorted the next procedure will depend upon the method employed in baling. These methods were long used and will be described first, after which a method now generally adopted throughout the Near East will be described. There are four ways of arranging the leaf in the bale: *Basma, Bachi-Bagli, Kaloup,* and *Tonga.*

The *Basma* (meaning pressed) method consists in arranging the sorted leaves to make *pastals* (bundles) by placing the leaves one upon the other much as one would arrange a pack of playing cards. The *pastals* are then placed in *siras* (layers) of uniform thickness with the butts of the leaves toward the outside. The *siras* are arranged one above the other in a press box until a mass of standard weight is reached. Finally pressure is applied to yield a compact mass, the bale. In making the bale the top, bottom, and one end are covered with cloth, usually burlap. When such a bale is subsequently opened for inspection, the layers can be separated much as the leaves of a book. Only leaf of superior quality is placed in *Basma* bales, hence the term *Basma* connotes both the method of baling and best quality leaf.

The *Bachi-Bagli* method consists in making *pastals* of fifteen to twenty leaves and then binding or tying them together. The *pastals* are then placed in layers in making the bales, the butts of the outermost ones always being directed toward the outside. There are two types of *pastals* as determined by the shape of the leaves. If the leaves are petiolate (*Kulaksis,* meaning earless or lacking auricles), as in the varieties Samsun, Bafra, Maden, Katerini, Brusa, Kuban Maikop, etc., the leaves are bound at the petioles to make narrow-*pastal, Bachi-Bagli* bales. If however, the leaves are not petiolate but instead are eared (*Kabakulak* or *Tik-kulak,* as in such varieties as Xanthi, Yaka, Prosotchani (Prosetchan), Prilep, and many others, the tie is placed around the lower part of the *pastal* and the bales become broad-*pastal Bachi-Bagli* bales.

The *Kaloup* method (*Armatha* method in Greece) consists in arranging the strings or festoons of cured leaves in layers in the press. Damaged or defective leaves and off-type ones are removed before placing the festoons in the press. This method is widely employed in western Turkey, the Aegean Islands, and parts of Continental Greece, especially in western Greece. It is best suited for areas that are very hot and dry during the harvesting season, that is for those in which curing proceeds very rapidly. Each bale contains from 50 to 150 strings of leaves.

The *Tonga* method consists in placing the loose leaves, completely without arrangement, in the press. This method is the least expensive, of course, and is preferred by American buyers. It is not regarded with favor by workmen, however, because it lessens the time required in sorting the leaf and making the bales and thus the total wages paid to them.

Regardless of which of these four methods is used in baling, it is most essential that the tobaccos be brought into proper order before sorting is begun and be maintained in order during baling. Proper order depends upon moisture content, different grades of tobacco having different moisture-content optima. Unless the leaves are sufficiently moist to be pliable and can be folded in the hand without breakage yet will crackle when being handled, they are not in proper order. Too dry leaves break when handled. Even if the best moisture conditions are maintained there will be breakage, the amount ranging from 2% to 8%. The broken leaf is usually packed separately, and constitutes the *kirinti* (fragments) grade. This grade is used domestically and usually does not enter export markets.

The *Basma* and *Bachi-Bagli* methods are known as the classical methods, the other two as the simplified methods. Choice of method is dictated primarily by economic considerations. It is readily apparent that a relation in the aromatic tobacco industry must be maintained among cost of production by the farmer, cost of manipulation by those who operate the storage depots, and cost to the ultimate buyer. The most expensive items in cost of manipulation may well be wages, the other costs being interest charges, capital investment in the storages and in the stocks of tobacco, cost of insurance, and losses as from breakage and molds. Fluctuation in the wages paid to labor and in market demand for tobacco have remained throughout the Near East causes of crises in the tobacco industry. Officials in control of the monopolies must exert every effort to maintain full-time employment of labor in order to satisfy the demands of the workers' organizations and to make operative the economic and social policies of the governments. As an outcome of these factors, competition in the world markets has resulted in a decline in amount of tobacco baled by the classical methods and a corresponding increase in the practice of baling by the simplified methods.

The simplified method of baling in general use throughout the Near East is commonly called the "American" method. It is a modification of the method of making *Tonga* bales in which leaves of grades I, II, and III of a given variety from one area or from several areas are blended. To do this the growers' bales are first placed for several hours in a room in which the tobacco can be humidified to the extent that the leaves are sufficiently pliable to be handled without breakage. The bales are then opened and the leaves spread upon a moving belt. Since the leaves stick together in the bales made by growers, they must first be separated from each other. This is done either by hand or by machinery. Many persons are required to separate the leaves by hand and to remove the undesirable ones as they are carried along on the belt, where-

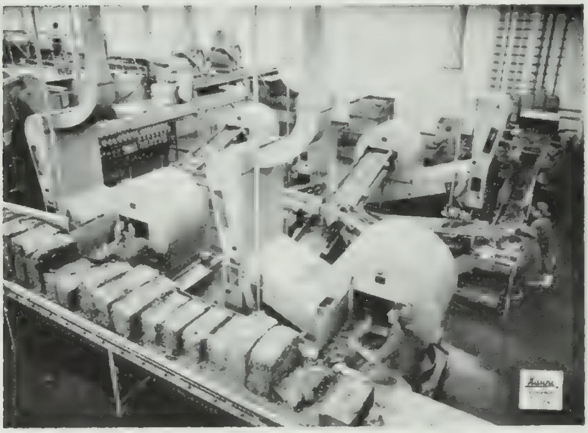


FIG. 79. Growers' bales of aromatic tobacco on the belt in the foreground. Two women are putting layers of leaves into the drums to separate them mechanically. The leaves are conveyed by air streams in the baffled columns. Courtesy H. U. Meissner, Die Hauni-Werke, Hamburg, Germany.

as few persons are needed when the leaves are separated by machinery. If a machine is used to separate the leaves it makes use of either of two devices, a circulating current of air and stirrers or beaters. In any case the leaves are introduced into a drum. As a result of the forced-air flow or of the fingers on the stirrer inside the drum the leaves are separated from each other. Thence they are conveyed by belt to a vertical, baffled column through which air is forced upward at a flow rate to complete the separation. Such leaves as stick together are returned to pass upward again through the baffled column. The separated leaves are then moved slowly along a belt. Workers stationed beside this belt remove off-grade or defective ones.

When this type of machinery is used to separate the leaves from each other, essentially all soil particles adhering to the leaves are removed, the dust being led out of the baffled column. The amount of dust removed can be appreciated only if one sees the accumulation from a single day's operation of such a machine.

The leaves remaining after removal of the undesirable ones are collected in a hopper from which they are taken and are placed in forms (baling frames) for baling. The baling frame consists of a collapsible steel structure with a floor, to which are hinged two curved sides. Each side is so shaped as to make a half of both ends. The sides can be held together with clamps. An extra frame or super is fitted above the baling frame to give the needed extra depth for filling the frame. A strong wooden cover to fit inside the press must be provided.

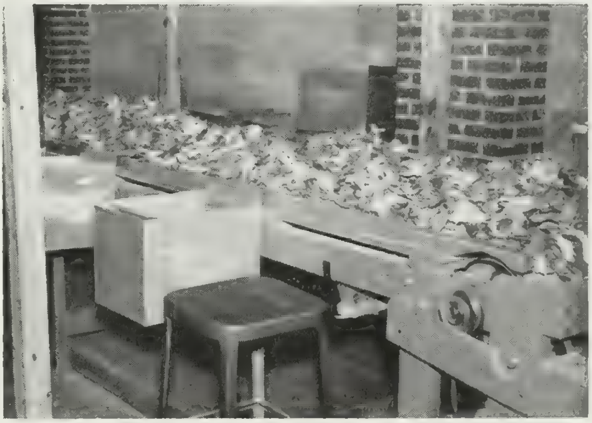


FIG. 80. The leaves on the belt have been separated from each other mechanically. Defective ones can be removed by 10 or 12 persons seated on each side of the conveyor belt. In the foreground is a stool and a box into which off-grade leaves are placed. Manipulation center at Anderson, South Carolina.

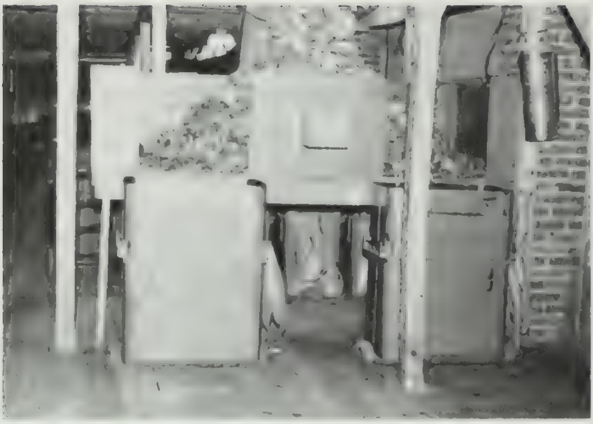


FIG. 81. At end of conveyor belt is a hopper from which the leaves are taken and placed in a press box for baling. A super rests atop the press box. Manipulation center at Anderson, S. C.

Making the bale—A burlap cover is spread over the bottom of the baling frame with the end and edges folded in until the sides of the box, when closed upward, will hold the burlap down. This strip of burlap should be long enough to cover one end and the top of the finished bale. The baling frame and super are then filled with leaves, which are distributed uniformly and pressed down with the hands and finally with the wooden cover. Usually the packer tramples upon the cover to compress the leaves while filling the baling frame. The filled

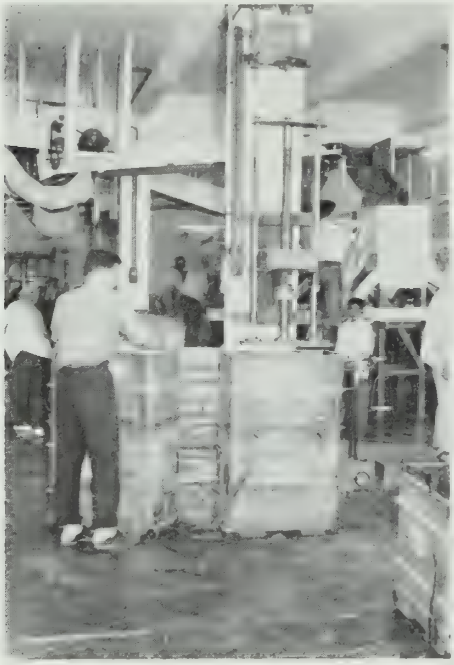


FIG. 82. Machinery for making bales of tobacco in a manipulation center in Greece.

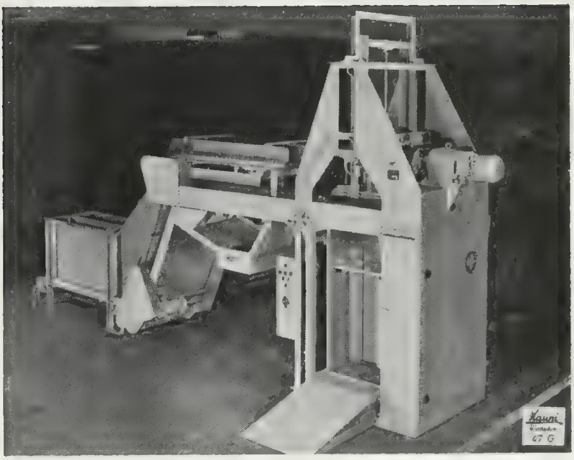


FIG. 83. Machine for forming bales of a given uniform size and weight. Courtesy M. U. Meissner, Die Hauni-Werke, Hamburg, Germany.

frame is weighed on a nearby scales, and each finished bale has the same weight. A strong cover is then clamped securely at the top of the frame. The filled frame is then placed under an hydraulic press, where it remains under pressure for a half hour or more. Upon release of the pressure, there is only a small amount of expansion of the bale and it is then ready to be covered with burlap.

First the edges of the cover should be folded. The cover should be sewed over the bale with a sack needle threaded with a double-cord. The needle is first passed through the center of the burlap at the bottom of the bale and then the loose ends of the cord are pulled through the loop. The loose ends are next threaded on the needle and passed through the center of the edge of burlap at the top of the bale. Then the stitching is continued, one string being used to the right side of the

FIG. 84. Newly made bales of uniform weight properly labeled, ready for removal to a storage. Manipulation center in Anderson, South Carolina.

bale and the other to the left. When the stitching is completed, the strings are tightened by taking up the slack, beginning with the first stitches.

After the tobacco is baled a tag is attached to each bale. Such data as grade of tobacco, variety, date of baling, weight, etc., are indicated on this tag. The bales are then ready to be placed in storage to undergo fermentation.

Fermentation

Once the tobaccos have been sorted and baled at the storage depots, according to standards demanded by prospective buyers, who are usually the agents of cigarette manufacturers, they must be placed in storages to undergo fermentation. The process of fermentation, as applied to each of the several types of tobacco, has been studied ex-

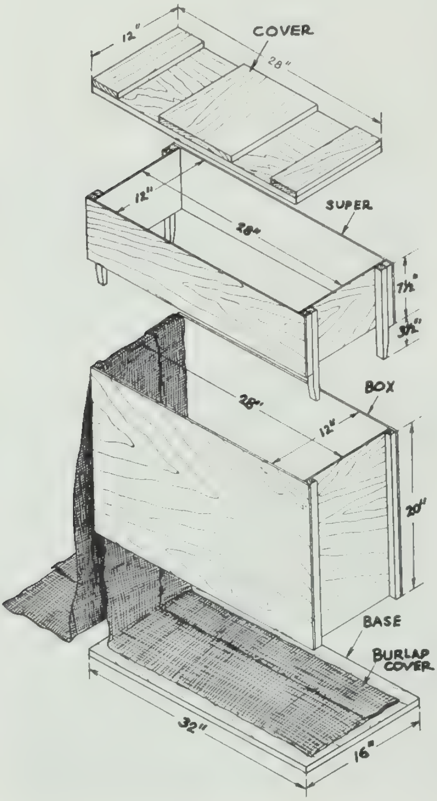
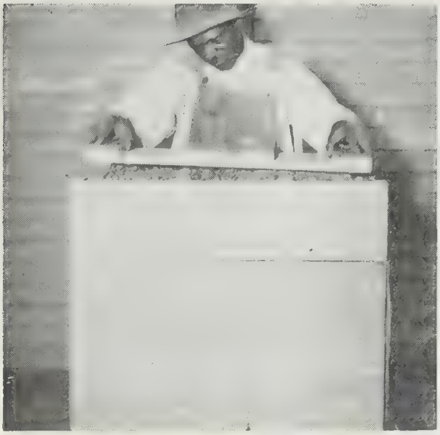
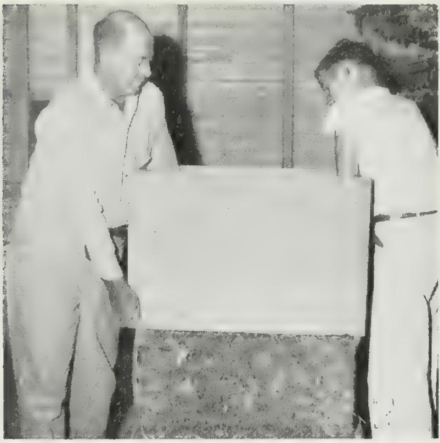
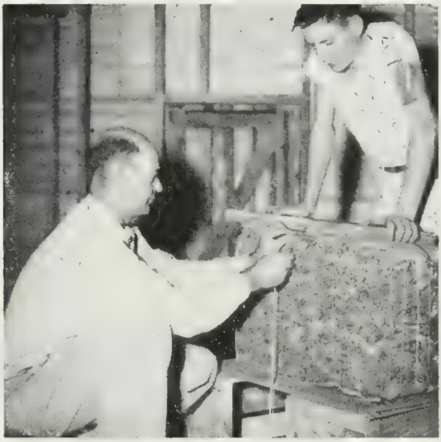


FIG. 85. Sketches of a wooden press-box and super.

FIG. 86 (on facing page). Operations, in sequence, in making a tonga bale by use of a wooden press-box.







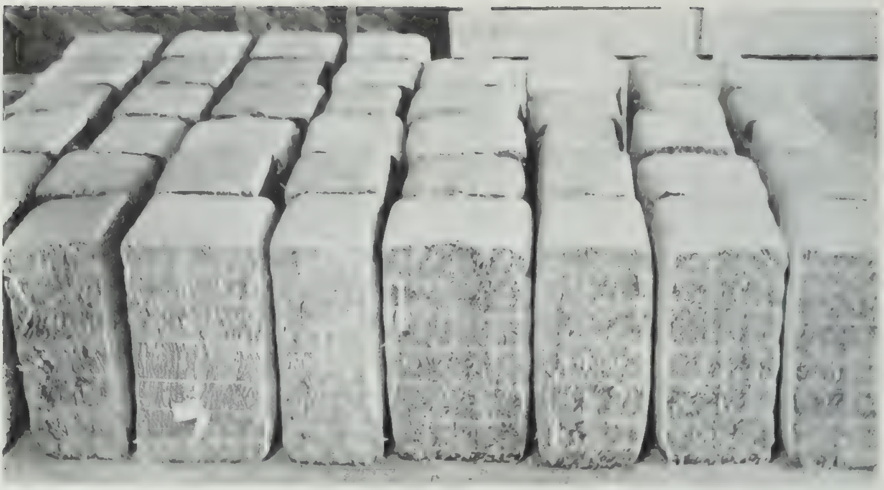


FIG. 87. Bales of varying weights made by use of wooden press-box.

tensively. These studies have involved the fermentative processes that are initiated by enzymes present in the leaf, and also by chemical decompositions or degradations and polemerizations that are not initiated by enzymes, and those changes for which micro-organisms are responsible. They have also involved the employment of chemical analyses to determine the constituents that are fermented and the extent to which these substances are changed. Lastly, studies of fermentation have been concerned with the interactions of temperature, moisture, and air (oxygen), and with techniques and devices to regulate or control these environmental factors. No attempt will be made to review these many studies; only a selected few that have direct bearing on the fermentation of aromatic tobaccos will be considered.

Investigation of the biochemistry of curing and fermentation of tobacco have been summarized and thoroughly documented by Bodnar and Barta (1935). The results of all investigations of these problems accord in showing that under natural conditions of curing, so long as the cells are alive, the important changes that occur are respiratory. Bacteria and other micro-organisms on the leaf surface have no role in the curing process although they contribute to the fermentative processes during aging. During curing, even after water loss reaches the point that the leaf cells are no longer alive, the enzymes present, mainly oxidase, peroxidase, catalase, and amylase, continue their activity. These enzymes continue to act so long as oxygen is available and conditions of moisture and temperature are favorable. As a result starch is changed to soluble sugars and acids. Pectic materials are degraded. Chlorophyll decreases. Ether-soluble materials, i.e., waxes and resins, are decreased. Ammonia and acids are formed from proteins and albuminoid substances. Nicotine content decreases. These fermentative changes thus are largely oxidative and reductive in nature. It must be admitted however, that the improvements in methods of fermenting tobaccos now being employed by those who operate storages or by the manufacturer have come into practice, to a great extent, as the result of empirical knowledge acquired in the industry itself, rather than as the result of fundamental studies in research laboratories.

The manipulative procedures associated with the fermentation of aromatic tobaccos must be regarded as an art. In actual industrial practice the manipulations are done empirically by persons who have acquired such knowledge from experience. Almost universally fermentation is permitted to proceed naturally by taking advantage of elevated summer temperatures, providing proper ventilation, and controlling the relative humidity within the storage rooms. Experience has also shown that if the leaves are too moist when baled they will not ferment properly but the tobacco will darken and the aromatic substances will volatilize. Too moist tobacco, moreover, is liable to spoilage from molds. On the other hand, if the tobacco is too dry it does not ferment at all or may ferment only to a slight extent. An experienced person who supervises the fermentation can judge the moisture content and the course of the fermentation by slipping his hand into the bale after loosening the twine that binds the bale and keeps the leaves closely compressed. The storage rooms must have ample windows for ventilation, and the air should be changed completely at least once a day. A source of water vapor for humidification should be provided to keep the relative humidity of the ambient air between 65% and 75%. A storage temperature during fermentation of about 20°C. is optimum. At the end of fermentation the best storage temperature is within the range of 10°C. to 15°C. Careful supervision alone in the regulation of moisture, temperature, and aeration assures proper fermentation. Properly fermented leaf has a uniform color, and the aroma that develops is characteristic of the variety and grade for each region where the given variety was grown.

Two fermentations are characteristically necessary for development of the best aroma and taste, but the manufacturer usually buys tobacco after it has undergone the first fermentation. He stores it for one or more years before using it in cigarettes. Andreadis (1940), who has carefully studied the many features of aromatic tobacco fermentation, found that some lots of tobacco will ferment slightly each spring for five to ten years. The less waxy, less resinous kinds require more than two years to ferment properly when subjected to conditions favorable for natural fermentation.

The first fermentation begins with the advent of warm weather in spring. It may continue for two or three weeks only or may last for as long as three months, depending mainly upon the hygroscopicity of the tobacco. The bales should be arranged close together and in a single layer for the first ten to fourteen days after the bales are made, and should be turned daily following a definite positional routine such as first with the edges down, then ends down, and then sides down. Then they should be placed in double tiers for two or three weeks, and the tiers reversed at intervals. The tiers should never exceed two or three for best results.

The temperature within the bales during fermentation tends to parallel that of the ambient air. It may rise to a height of 40°C., but should not exceed 35°C.; otherwise aroma and taste are adversely affected. If the temperature within the bale reaches 40°C., it indicates that the moisture content exceeds that which is optimum, namely, with-

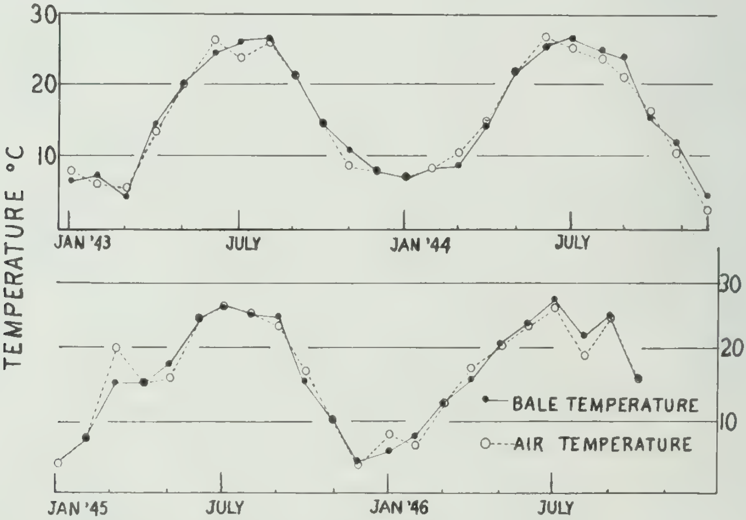


FIG. 88. Course of temperature changes within fermenting bales and that of the ambient air of the storage. From data by Wolford, (1948).

in the range of 12% to 16%. Bales having too high temperatures should be taken apart to permit lowering of the moisture content, and then should be rebaled. As anticipated, less close attention to details of manipulation is required for *Basma* and *Bachi-Bagli* bales than for *Tonga* bales.

The foregoing procedures, established by Andreadis (1940), accord with findings gained from our studies of fermentation of aromatic tobacco grown in North Carolina. Other facts of interest are revealed from chemical analyses that show the nature and extent of changes in constituents that occur during fermentation. The data on this point, shown in Table XXIV, are taken from studies by Moffett (1942).

As is evident, during aging there is a loss in content of amino nitrogen, organic acids, and starch with a slight decrease in pH. In these experiments there was no appreciable change during aging, however, in petroleum ether-extractable substances, alcohol-extractable substances, sugars, nicotine, total nitrogen, protein nitrogen, and water-soluble nitrogen. These results are not in agreement with others, next to be considered.

Darkis and Hackney (1952) considered the extent of the changes that occur in flue-cured, Burley, Maryland, and aromatic tobaccos during aging or fermentation. Their resumé of the changes in aromatic kinds is included in Table XXV.

The data in Table XXV show that, without exception, there is a decrease during aging of each constituent or compound.

Another somewhat more extensive study of the fermentation of North Carolina-grown tobaccos, Brusa, Katerini, Stanimaka, Ayasolouk, and Smyrna, was made by Wolford (1948). A summary of his results showing the constituents before fermentation, after the first fermentation, after the second fermentation, and the percentage changes that occurred, by grades, is given in Table XXVI.

The changes shown are the composite, by grades, of the five varieties analyzed. The greater decreases in constitutents occurred during the first fermentation, as expected, but the tobaccos changed significantly during the second fermentation. Each constituent decreased in amount during fermentation. It seems reasonable to assume that changes occurred in many other constituents, some of them very slight, percentage-wise, but they were nevertheless very important in contributing to the improvement of aroma and flavor.

Series of investigations involving the fermentative changes in oriental

TABLE XXIV. CHEMICAL COMPOSITION OF U.S.-GROWN AROMATIC TOBACCO
(percentage of dry weight)

Variety	*Priming*	*pH*		*Non-vol. acids*[1]		*Nicotine*		*Total N*		*Protein N*		*Water sol. N*	
		cured	*aged*	*cured*	*aged*	*cured*	*aged*	*cured*	*aged*	*cured*	*aged*	*cured*	*aged*
Brusa	1	5.12	5.18	17.00	16.07	1.38	1.20	2.25	2.40	1.03	1.02	1.04	1.16
	2	4.91	5.00	12.68	13.05	0.90	0.72	2.10	2.20	1.05	1.02	0.95	0.98
	3	4.87	4.79	14.48	14.79	0.79	0.67	2.29	2.26	0.96	1.02	1.23	1.10
	4	4.78	4.65	17.91	14.54	0.74	0.74	2.44	2.32	1.17	1.15	1.21	1.18
	5	4.71	4.62	17.58	15.08	0.91	0.70	2.74	2.59	1.24	1.13	1.47	1.34
	6	4.71	4.64	15.38	14.90	0.79	0.70	3.13	2.99	1.33	1.32	1.66	1.60
Smyrna	1	5.53	5.52	18.42	16.34	0.80	0.75	1.86	1.89	0.99	1.00	0.78	0.78
	2	5.34	5.19	16.74	14.94	0.60	0.52	1.90	1.81	0.98	0.96	0.85	0.86
	3	5.29	5.12	15.86	15.38	0.49	0.38	1.97	1.93	1.00	1.02	0.81	0.82
	4	5.35	5.08	16.97	15.16	0.49	0.41	2.11	2.07	1.00	1.00	1.00	0.90
	5	5.17	5.02	18.74	17.81	0.42	0.37	2.20	2.11	1.06	1.07	1.07	0.94
	6	5.10	4.99	17.33	17.80	0.36	0.34	2.32	2.44	1.12	1.11	1.15	1.26
Hendek	1	5.66	5.24	19.50	18.48	0.96	0.92	2.07	1.83	1.10	1.00	0.88	0.84
	2	5.18	5.21	17.55	17.02	0.72	0.75	2.43	2.30	1.22	1.13	1.06	1.14
	3	5.14	5.11	16.36	16.37	0.66	0.69	2.72	2.60	1.14	1.25	1.45	1.31
	4	4.93	4.99	17.29	17.74	0.67	0.44	2.38	2.28	1.09	1.05	1.25	1.09
	5	4.81	4.73	16.54	16.68	0.72	0.63	2.51	2.52	1.16	1.17	1.21	1.30
	6	—	—	—	—	—	—	—	—	—	—	—	—
Xanthi-Yaka	1	5.76	5.74	18.75	17.54	0.57	0.68	2.00	1.93	1.15	1.28	0.69	0.70
	2	5.27	5.29	17.60	16.95	0.49	0.37	2.42	2.31	1.25	1.24	0.98	0.94
	3	4.99	4.89	17.45	15.91	0.50	0.44	2.32	2.34	1.17	1.17	0.99	1.08
	4	5.08	4.81	19.86	18.89	0.50	0.48	2.51	2.45	1.20	1.18	1.14	1.10
	5	—	—	—	—	—	—	—	—	—	—	—	—
	6	—	—	—	—	—	—	—	—	—	—	—	—

tobaccos have been made at the Tobacco Experiment Station in Krasnodar, Russia. Shmuk (1934), for example, noted that fructose is the primary sugar in fermented leaf and that glucose, mannose, and galactose were practically absent. Obabko (1940) found that sugars decreased in proportion to the increase in maintained partial pressure of oxygen during fermentation. Under anaerobic conditions, however, there was no increase in sugars, but there was increased accumulation of polyphenols. At the same time, the content of citric acid increased but malic acid decreased. He was unable to detect any change in aroma and taste of Samsun and Sukhum tobaccos when fermented under the different conditions of partial pressures of oxygen.

Artificial fermentation has been given extensive consideration by Mihailovici and Constantinescu (1936), Vlădescu and Dimofte (1938), and Zaporojanu (1939), Mihailovici and Trafiuc (1939) in Rumania, and by Giovannozzi (1955, 1958a, 1958b) and Bartolucci (1958) in Italy, and by Popov (1938) and Vesilinov (1959) in Bulgaria.

TABLE XXIV. *(continued)*

	Amino N		Total sugar		Red. sugars		Starch		Total carbohydrate		Pet. ether ext.		Alc. ext. substances	
	cured	aged	cured	aged	cured	aged	cured	aged	cured	aged	cured	aged	cured	aged
1	0.348	0.392	2.56	2.90	2.24	2.15	1.75	1.84	4.05	4.45	5.30	4.95	25.64	25.25
2	0.331	0.382	2.95	2.88	2.86	2.53	2.84	2.31	4.48	4.90	5.21	5.76	25.11	24.14
3	0.501	0.380	2.18	1.99	1.88	1.68	2.52	2.43	4.48	4.22	5.70	5.87	24.64	22.34
4	0.529	0.467	2.23	2.16	1.71	1.68	2.67	2.28	4.68	4.72	5.94	5.87	23.32	23.78
5	0.569	0.516	1.93	2.35	1.31	1.71	2.73	3.01	4.47	5.13	6.29	7.02	24.88	24.63
6	0.629	0.601	2.90	2.59	2.40	1.92	2.85	2.96	5.46	5.29	8.34	7.74	26.81	27.29
1	0.294	0.279	5.88	4.64	5.73	4.48	3.78	2.55	9.07	6.73	5.96	5.72	19.53	17.25
2	0.292	0.248	8.41	10.71	8.25	10.25	3.44	4.08	11.01	13.72	5.96	5.96	22.55	24.41
3	0.316	0.270	4.85	6.04	4.55	5.87	3.51	3.46	7.88	8.90	6.68	7.11	20.53	22.73
4	0.481	0.390	4.60	4.26	4.38	4.10	3.34	3.00	7.48	6.83	8.28	8.09	20.55	22.00
5	0.424	0.399	4.45	4.15	3.83	3.72	3.50	2.89	7.51	6.63	7.59	8.10	21.98	22.18
6	0.424	0.450	4.87	4.13	4.21	3.93	3.93	2.42	8.31	6.14	6.83	7.89	23.33	23.53
1	0.279	0.272	2.70	4.19	2.27	3.80	2.91	2.92	5.34	6.69	4.52	4.46	18.18	19.94
2	0.368	0.363	2.66	2.73	2.31	2.39	3.14	2.96	5.53	5.42	3.39	3.69	26.16	20.21
3	0.582	0.493	2.14	2.11	1.73	1.68	2.98	2.69	4.91	4.59	4.03	4.10	18.78	19.10
4	0.502	0.455	2.10	2.23	1.48	1.95	2.60	2.51	4.49	4.52	4.92	4.12	18.20	19.99
5	0.571	0.424	3.82	3.85	3.25	3.21	2.75	2.46	6.19	2.93	5.60	4.72	23.99	25.52
6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1	0.331	0.276	1.77	1.63	1.39	1.54	1.58	2.55	3.17	4.02	4.28	4.28	15.38	15.54
2	0.413	0.437	2.75	2.97	2.37	2.61	2.13	2.84	4.61	5.51	3.78	3.72	23.12	23.10
3	0.416	0.430	2.21	2.17	1.96	1.95	2.51	2.86	4.50	4.81	4.81	5.00	19.74	19.27
4	0.489	0.496	2.40	2.46	2.03	2.12	1.90	2.07	4.06	4.28	5.67	5.47	21.65	22.00
5	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—	—	—	—	—	—	—

[1] cc N/10 Alkali per gm. tobacco.

Mihailovici and his associates used special cabinets in which they placed bales weighing 25, 50, or 75 kilograms. They employed four different initial moisture contents, 14% to 15%, 17% to 18%, 20% to 21%, and 24%. The varieties used were Molovata (small leafed) and Ghimpatzi (large leafed). The ambient temperature was maintained at approximately 25°C. (77°F.) and 30°C. (86°F.). During a fermentation period of twenty-five days bales of 25 kilos and 50 kilos with 17% to 18% moisture and at 25°C. lost 4% to 6% of their dry weight. At the lower moisture level fermentation was less complete and at the higher levels the tobaccos discolored or became moldy regardless of size of bales. Even at 17% initial moisture content and at a maintained temperature of 30°C. the large leafed Ghimpatzi did not ferment satisfactorily. Vlădescu and Dimofte (1938) followed the changes in nitrogenous constituents in Yaka, Molovata, Ghimpatzi, Ialomitza, Banat, and Sătmărean tobaccos. They, too, used cabinets in which they maintained an ambient temperature of 25°C., and a relative humidity of 75%, at varying initial moisture contents. Their results, in general, were like those obtained by Mihailovic and his associates.

Giovannozzi (1955) found a loss of 2.02% in dry matter at the end of a twenty-five day period of artificial fermentation as compared with 0.65% when natural fermentation occurred. He accounted for part of this loss in weight by the fact that there was a reduction of 20% in reducing sugar under conditions of artificial fermentation, whereas the loss was only 2.3% under natural fermentation. The tobacco was kept at temperatures of 47°–52°C. and at relative humidities within the range of 70% to 80%.

Bartolucci (1958) employed controlled temperature at 41°C. and controlled humidity at 70% during fermentation of Xanthi Yaka, Perustitza, and Erzegovina tobaccos. The periods of fermentation for these three varieties were ten, thirteen, and eighteen days, respectively. As a result of being subjected to artificial air-conditioning for these short periods both flavor and aroma were improved and the tobacco was judged to be better than the naturally fermented ones.

Evidently there is general agreement that color is nearly always affected adversely when aromatic tobaccos are artificially fermented, and there seems little to commend this practice. It appears that the most important reason for using artificial fermentation is that it may make possible earlier marketing of the crop to manufacturers, and in so doing permits earlier returns on invested capital. However the characteristics of artificially fermented tobaccos are quite unlike those of naturally fermented ones, for which reason manufacturers are not favorably impressed with tobaccos subjected to artificial fermentation.

TABLE XXV. EXTENT OF CHEMICAL CHANGES THAT OCCUR IN AROMATIC TOBACCO DURING AGING *(percentage of dry weight)*

Constituents	*Content before aging*	*At end of 1 year*	*At end of 2 years*
Total nitrogen	2.01	1.93	1.91
Protein nitrogen	0.95	0.93	0.92
Amino nitrogen	0.217	0.156	0.145
Nicotine	1.0	0.92	0.86
Petroleum ether extractive	6.79	6.50	6.33
Starch	5.18	4.43	4.38
Soluble sugars	11.03	9.03	8.78
pH	4.40[1]	4.37[1]	4.31[1]

[1] Not percentage.

TABLE XXVI. COMPARATIVE FERMENTATION CHANGES IN ALL VARIETIES FROM CROPS OF 1942, 1943, AND 1944 *(percentage of dry weight)*

	Grades	Total N.	Protein N.	Amino N.	Nicotine	Pet. ether ext.	Alcohol ext.	pH[1]	Total sugar	Starch	Total carbo-hydrate
Before fermentation	1	2.50	1.14	0.364	0.94	7.65	29.14	4.32	6.49	3.93	11.03
	2	2.44	1.04	0.382	0.99	6.83	28.14	4.43	6.04	3.90	10.37
	3	2.26	0.96	0.329	1.15	6.16	28.13	4.52	6.46	3.24	10.00
	4	2.15	0.96	0.298	1.23	5.63	26.93	4.64	5.91	2.96	9.05
After 1st fermentation	1	2.49	1.14	0.304	0.79	7.14	28.60	4.31	5.16	3.66	9.36
	2	2.39	1.01	0.290	0.88	6.31	28.34	4.42	4.87	3.70	8.98
	3	2.19	0.93	0.224	0.98	5.82	27.66	4.50	4.87	3.08	8.57
	4	2.14	0.93	0.240	1.01	5.15	26.31	4.58	4.57	2.94	7.84
After 2nd fermentation	1	2.41	1.14	0.268	0.75	6.63	28.11	4.27	5.08	3.76	9.26
	2	2.29	1.01	0.254	0.80	6.16	27.46	4.33	4.66	3.37	8.39
	3	2.11	0.91	0.214	0.90	5.56	27.37	4.38	5.15	2.98	8.45
	4	2.07	0.94	0.205	1.03	5.05	26.33	4.48	4.57	2.72	7.59
% decrease after 1 yr.	1	−0.4	0	−16.4	−15.9	− 6.7	−1.8	−0.2	−20.5	− 6.9	−15.1
	2	−2.0	−2.9	−24.1	−11.1	− 7.6	+ .07	−0.2	−19.4	− 5.1	−13.4
	3	−3.1	−4.2	−31.9	−14.8	− 5.5	− 1.7	−0.4	−24.6	− 4.3	−14.3
	4	−0.5	−3.1	−19.5	−17.9	− 8.5	− 2.3	−1.3	−22.6	− 0.7	−13.4
% decrease after 2 yrs.	1	−3.6	0	−26.4	−20.2	−13.3	− 3.5	−1.2	−21.7	− 4.3	−16.0
	2	−6.1	−2.9	−33.5	−19.2	− 9.8	− 2.4	−2.3	−22.8	−13.6	−19.1
	3	−6.6	−5.2	−34.9	−21.7	− 9.7	− 2.7	−3.1	−20.4	− 8.0	−15.5
	4	−3.7	−2.1	−31.2	−16.3	−10.3	− 2.2	−3.4	−22.7	− 8.1	−16.1

[1] Not a percentage.

Apparently no one has been concerned with the microflora of aromatic tobacco for the purpose of learning the role of micro-organisms in fermentation, the kinds of organisms involved, and the changes that specific ones effect. On the basis of findings, however, that bacteria occurring on cigar tobaccos are able to decompose nicotine (Jensen and Parmele, 1950, Frankenburg *et al.*, 1955) one may assume that bacteria occurring on aromatic kinds similarly attack nicotine. The writer has been able to obtain a measure of support for this assumption. He isolated several species of bacteria from the leaves and seed of oriental tobacco, as well as species of molds. These organisms were regarded as among the common soil-inhabiting species. None of the molds when cultivated on a medium consisting of tap water to which nicotine was added in dilute solutions was able to utilize nicotine. But several of the different species of bacteria were able to remove the nicotine completely or almost entirely with a period of seventy-two to eighty-four hours when incubated at room temperature. These results confirm the findings of several investigators in showing that nicotine can serve as the sole source of carbon and nitrogen for certain species of bacteria.

Similarly it has been established that bacteria are able to decompose the alkaloids, nornicotine and anabasine, closely related to nicotine, and in so doing they act similarly by hydroxylation and dehydrogenation.

Summary

Manipulation as applied to the handling of aromatic tobaccos includes sorting, baling, and fermenting the cured leaves. These operations are performed at storage depots or magazines to prepare the tobacco for exportation or for use by manufacturers of cigarettes.

As a general practice the usable leaves are sorted into four major grades of which grade I, II, and III enter into world trade and grade IV is used domestically. Formerly sorting was done entirely by hand but now is becoming partly mechanized.

The bales of each variety are made to have a standard size and weight. As a result storage space is utilized most advantageously in the fermentation rooms and in the holds of ships when the tobaccos are exported.

Fermentation requires that temperatures and relative humidity within the storages be carefully controlled. A systematic turning of bales is employed to aid fermentation. During the process of fermentation a series of oxidative and reductive changes of the tobacco constituents occurs, involving primarily the content of carbohydrates, proteins, and nicotine. The net result of fermentation is improvement in the product. Usually aromatic tobaccos are exported only after undergoing one fermentation, and they will improve further if allowed to ferment again.

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Chapter Nine

THE CHEMISTRY OF AROMATIC TOBACCOS

Introduction

Tobacco has been subjected to more extensive chemical studies than has any other plant species. Multiplied thousands of reports involving such studies have been published in many different languages. In spite of these multitudinous reports, however, much remains to be done. Anyone who attempts critically and adequately to review, interpret, and summarize this information in one brief chapter or even in one large volume will be forced to conclude that the task is utterly impossible of accomplishment. All that any one person can hope to do is to introduce the subject, call attention to what he regards as important, established facts, and to indicate what aspects are controversial and little known. It is hoped that by so doing it will be possible to stimulate a continuing interest in the many complex problems of tobacco chemistry.

An appreciation of the scope and number of studies that have been made in the field of tobacco chemistry can be gained from the volume by Brückner (1936) and such recent publications as the book *Chemistry and Technology of Tobacco* by Shmuk (1953), and the condensation by Johnstone and Plimmer (1959) having 419 references to reports on the constituents of tobacco and tobacco smoke.

During recent years claims that tobacco smoke is carcinogenic have provided the stimulus for numerous investigations of the chemistry of the tobacco leaf and of the products of its combustion. The results of such studies will not be discussed herein even though they relate to the composition of tobacco itself. This matter is considered briefly in Chapter V. Many of the older investigations deal with such constituents as the mineral elements of which the ash is composed, starch, sugars, organic acids, proteins, albumins, nicotine, amino-acids, resins, and waxes. Recent chemical studies, however, stress the nicotine content of tobaccos in its relation to nearly a dozen other alkaloids, and indicate the importance of numerous groups of other constitutents such as polyphenols, sterols, hydrocarbons, pigments, volatile and non-volatile organic acids, various aromatic and aliphatic substances, and products arising from the pyrolysis of these constituents. Many constituents exist in trace amounts only, hence their presence is detectable only by means of techniques involving chromatography and spectroscopy. Techniques for the isolation and identification of many constituents remain to be developed. Moreover, in recent years, it has been found that tobacco smoke contains many of the same constituents as are in the leaf, but there are also many others produced by pyrolysis. Nicotine is among the bases identified in the smoke, and additionally nornicotine, myosmine, and pyridine. A large number of the low-molecular-weight straight-chain aliphatic acids as well as numerous dicarboxylic acids, hydroxy acids, and keto acids of the aromatic series have been isolated from tobacco smoke and identified. Chlorogenic acid, a phenol, occurs in the leaf of all types of cultivated tobacco. Evidence of the presence in smoke of about seventy hydrocarbons has been obtained by use of techniques involving infra-red spectrometry, mass spectrometry, and chromatography. Both saturated and unsaturated low-molecular-weight hydrocarbons are demonstrably present by one or the other of these techniques.

The principal types of tobacco have been shown to be characteristically different in chemical composition. More appears to be known about the constituents of cigar tobaccos, Burley tobaccos, and flue-cured tobaccos than about tobaccos of the aromatic type. This situation is due largely to the fact that the use of tobaccos from the Near East in making blended cigarettes is a relatively recent occurrence. The chemical differences between types are partly attributed to genetic differences but mainly to environmental effects arising from differences in soil and climate, fertilizer practices, and methods of cultivation, harvesting, curing, storage, fermentation, and aging. It is well established that when meteorologic and edaphic conditions are optimum, as happens occasionally, vintage crops are produced, and that the quality of the crop among varieties of a given type is quite variable. Moreover the leaves of different positions on the stalk differ in composition. And, as will also be indicated, there exist patterns of distribution of constituents within any given leaf, some constituents, for example, being more abundant in tissues near the leaf tip than near the base of the leaf, and more abundant near the leaf margin than near the midrib.

In this account of the chemical composition of aromatic varieties consideration will be given especially to (1) differences among varieties; (2) differences among grades of the same and different varieties; (3) differences resulting from spacing of plants; (4) differences attributable to time of planting; and (5) differences among primings. It will be apparent that the results from different investigations are not always in accord, and that the data have been selected arbitrarily and consequently do not include all published ones that are pertinent. It is only hoped that there has not been an overassemblage of tabular data to the point that the mass of material tends to become indigestible and confuse the reader.

It may also be suggested that in the past greatest emphasis has been placed upon the most abundant constituents of tobacco and tobacco smoke. It may well be that materials present in trace amounts are enormously important and that many of such constituents remain to be isolated and characterized. Certainly the chemistry of tobacco offers an inviting field for research, whether the investigator is inclined toward either its pure or applied aspects.

Differences among varieties

Vlădescu and Dimofte (1935) made a series of analyses of tobaccos of third quality of several varieties widely grown in Turkey. Their findings as regards nitrogenous materials, carbohydrates, polyphenols, and ash are given in Table XXVII. Wide differences in constituents among varieties are clearly shown by the above data. This is due to the fact that the samples represent each of the major tobacco-growing districts. Probably these tobaccos represent the crop of a single season and perhaps, too, all had been fermented prior to sampling. Vlădescu and Dimofte (1936), made similar analyses of Macedonian varieties, with the results shown in Table XXVIII.

The relative amounts of constituents in these varieties approximate each other remarkably closely. In explanation of these similarities it may be noted that all were grown in a very small geographic area under almost identical climatic conditions and on quite similar soils.

An extensive series of analyses for crops grown in Turkey, Greece, and Bulgaria was made in Germany by Pyriki (1941). He grouped the varieties that he analyzed on the basis of the regions in which they had been grown, combining the data of varieties and grades from several

TABLE XXVII. ANALYSES OF THIRD QUALITY VARIETIES OF AROMATIC TOBACCOS GROWN IN TURKEY *(percentage of dry weight)*

Variety	*Total nitrogen*	*Albuminoid nitrogen*	*Nicotine*	*Total carbo-hydrates*	*Polyphenols*	*Ash*
Smyrna (Axav)	1.85	0.95	1.20	12.68	3.42	13.27
Artvin	2.72	1.03	1.79	9.97	1.46	12.76
Brusa	2.70	1.13	2.02	10.33	3.34	12.67
Bafra	2.62	0.99	1.56	8.65	3.18	12.01
Duzçe	2.65	1.06	1.56	8.09	4.62	14.98
Erbaa (Tachova)	2.77	1.02	2.95	7.24	1.47	15.25
Samsun Maden	2.64	1.12	0.73	7.90	2.56	12.79
Hendek	2.69	1.13	2.67	6.29	3.27	12.42
Gönen	2.43	1.02	2.04	5.52	3.65	13.70
Platane	2.79	1.06	3.34	5.30	4.32	13.88
Trabzon	3.14	1.04	3.48	4.52	2.42	13.85
Kirklareli	2.83	1.13	2.56	4.60	3.44	13.46
Edirne	3.31	1.13	3.60	3.53	0.39	18.02
Izmit	3.15	1.14	2.21	3.31	0.41	16.57
Sinop	3.34	1.19	2.62	2.72	2.08	14.56

crops into average figures to indicate the maximum amount, the minimum amount, and the average of each constituent. The varieties from western Thrace, grades I-IV, of the 1936-1938 crops included Xanthi, Xanthi-Yaka, and Xanthi-Djebel; those from eastern Macedonia, grades I-IV, of the 1936-1938 crops, included Drama, Kavala, Zichna, Pravista, Machaladakia, Nigrita, Porroia, Kabakulak, and Porroia Basma; those from western Macedonia, grades I-III, of the 1937 crop, and central Macedonia, grades I-IV of the 1937-1938 crops, included Käilaria, Karadog, and Kilkis; those from Southern and Macedonian Districts of Bulgaria, grades I-VI of the 1937-1939 crops of Djebel, and grades I-VIII of the same years' crops of Melnik, Nevrokop, Peritch, Doupnitza, and Gorna-Djumaja, and grades I-VI of the same years' crops of Orta Koeury, Perustitza, Plovdiv-Yaka, Kouchoukavak, and Harmanli; those from the Smyrna region, grades I-IV of the 1936-1938 crops, included

TABLE XXVIII. COMPOSITION OF TOBACCOS FROM MACEDONIA *(percentage of dry weight)*

Variety	*Total nitrogen*	*Albuminoid nitrogen*	*Nicotine*	*Remaining substances*	*Carbo-hydrates*	*Ash*
Djebel	2.36	1.05	0.90	17.63	13.44	15.34
Karchi-Yaka	2.39	1.06	1.34	15.86	11.72	15.94
Mahala	2.23	0.93	1.74	13.16	10.21	18.56
Zichna	2.31	1.02	1.36	12.71	9.03	17.13
Xanthi-Yaka	2.62	1.10	1.62	11.78	8.25	17.22

TABLE XXIX. CONSTITUENTS OF AROMATIC TOBACCOS GROWN IN BULGARIA, GREECE, AND TURKEY DURING 1936-39. DATA FOR ALL VARIETIES GROUPED ACCORDING TO REGIONS *(percentage of dry weight)*

Regions	*Number of samples*	*Nicotine*			*Total nitrogen*			*Ash*		
		max.	*min.*	*av.*	*max.*	*min.*	*av.*	*max.*	*min.*	*av.*
GREEK TOBACCOS										
Western Thrace	30	1.48	0.66	0.98	3.10	2.53	2.63	21.74	14.45	18.31
Eastern Macedonia	49	2.73	0.52	1.17	3.60	1.92	2.61	24.61	12.97	17.26
Western Macedonia	12	1.88	0.54	1.03	3.21	2.36	2.68	23.02	18.47	19.36
Central Macedonia	44	1.20	0.38	0.81	3.25	1.81	2.46	20.74	14.34	17.81
Summary	135	2.73	0.38	1.00[1]	3.60	1.81	2.57[1]	24.61	12.97	17.85[1]
BULGARIAN TOBACCOS										
Djebel	17	1.27	0.40	0.77	3.10	2.12	2.58	22.58	13.20	17.49
Macedonian District	44	1.52	0.44	0.84	2.80	1.53	2.18	21.55	12.88	16.51
Southern District	45	2.80	0.76	1.62	3.02	1.97	2.42	24.20	15.04	18.73
Summary	106	2.80	0.40	1.08[1]	3.10	1.53	2.34[1]	24.20	12.88	17.61[1]
TURKISH TOBACCOS										
Smyrna region	54	1.55	0.14	1.02	2.89	1.49	2.07	23.96	11.73	18.29
Samsun region	35	2.21	0.14	1.01	3.29	1.88	2.65	25.43	12.53	16.97
Summary	89	2.21	0.14	1.01[1]	3.29	1.49	2.29[1]	23.96	11.73	17.32[1]

[1] Weighted average.

Ghiavourköy, Akhisar, Ödemis, and Muğla; those of grades I-IV of the 1937-1939 crops of the Samsun District included Samsun Maden, and Samsun Demet. A summary of the data from the report of Pyriki is presented in Table XXIX.

The data in Table XXIX show that aromatic tobaccos grown in different regions are strikingly different in chemical composition. One might ascribe these differences as due entirely to soil and climate were it not for the fact that the composition of different varieties is not alike even when all are grown in one and the same region.

Akkoyunlu (1947) analyzed the most important varieties of Turkish tobacco to determine the range in percentage of the different components. By so doing he was able to portray differences attributable to differences among samples and grades of a given variety. His data are shown in Table XXX.

Consideration of the data in Table XXX should convince anyone that varieties of aromatic tobacco, even those grown in the same region, are very different in composition from each other. In this case Artvin, Samsun, Trabzon, Bafra, and Tachova are from the Black Sea region; Izmit, Duzçe-Hendek, and Brusa are from the region near the Marmara

TABLE XXIX. *(continued)*

Reducing substances		*Soluble carbohydrates*			*Polyphenols*			*Resins and waxes*			*pH at 18° C*	
max.	*av.*	*max.*	*min.*	*av.*	*max.*	*min.*	*av.*	*max.*	*min.*	*av.*	*max.*	*min.*
20.04	12.78	13.81	3.13	8.28	6.39	2.38	4.50	11.41	8.22	9.70	5.46	4.83
21.22	12.14	15.67	2.96	8.01	6.42	2.27	4.03	11.50	6.13	9.33	5.65	4.84
20.00	13.97	15.26	4.46	9.76	5.10	1.97	4.21	10.00	6.61	8.30	5.45	5.10
26.30	17.92	18.56	6.00	12.81	7.76	3.09	5.11	9.05	7.09	8.90	5.49	5.03
26.30	14.34[1]	18.56	2.96	9.79[1]	7.76	1.97	4.66[1]	11.50	6.13	9.17[1]	5.65	4.83
22.61	16.38	16.08	4.17	10.80	6.84	2.72	5.48	9.72	7.19	8.63	5.37	5.03
27.18	18.40	19.80	4.10	15.04	9.70	3.14	5.36	9.34	5.52	7.06	5.50	5.03
22.13	14.31	16.40	4.16	10.00	5.73	2.79	4.21	10.85	7.85	9.01	5.43	4.99
27.18	17.32[1]	19.80	4.10	12.22[1]	9.70	2.72	4.89[1]	10.85	5.52	8.14[1]	5.50	4.99
27.22	15.70	20.18	1.60	10.79	7.34	1.26	4.91	12.19	6.77	9.86	5.44	4.98
20.85	10.60	15.18	0.41	6.16	7.07	2.36	4.44	11.60	7.50	9.02	5.93	4.81
27.22	13.70[1]	20.18	0.41	9.08[1]	7.34	1.76	4.72[1]	12.19	6.77	9.53[1]	5.93	4.81

Sea; the mixture of Aegean varieties is from the region that centers around Izmir; and the other samples are from eastern Turkey.

Regional differences

One of the most comprehensive investigations of the major constituents of aromatic tobaccos in that of Darkis, Hackney, and Gross (1947). Their samples were taken from bales of grades 1, 2, and 3 from stocks being held in storages. Each of the bales contained leaves from several different fields and from several different communities or villages. The samples were from crops grown in 1937 and 1938 in the Black Sea region and Smyrna region of Turkey and in the Macedonian and Thracian regions of Greece. Their data are shown in summary in Tables XXXI and XXXII.

These analyses show that the chemical composition of tobacco varies widely from year to year within each region. It may be assumed that soil differences, climatic differences, and varietal differences account for such variation, but no measure of the degree to which each of these factors operate to modify the composition of aromatic tobacco is known. As with other types of tobacco the crops of certain years are vintage crops.

It can be seen that there are consistent differences in composition among grades. Among the marked differences are those involving nitrogen. Leaves of the first grade, those of the *ütch* group, contain the least nitrogen, whereas top leaves of flue-cured tobacco and Burley tobacco have the greatest nitrogen content. Darkis *et al.* (1947) suggest that perhaps paucity of nitrogen in the top leaves is a consequence of the low level of soil fertility, and of the withdrawal of nitrogenous materials from the youngest leaves to provide for the growth of the flowers, capsules, and seed, the seedhead being permitted to mature in oriental tobaccos.

The data also show that nitrogenous constituents and carbohydrate constituents are inversely correlated; i.e., those tobaccos having the least nitrogenous constituents have the greatest carbohydrate content. Similarly, least total acids are possessed by those tobaccos having the greatest carbohydrate content. Other investigators have shown that quality is correlated with content of nitrogenous materials, carbohydrates, and acids. Piatnicki (1927), from analyses of tobacco grown in the Black Sea area, noted an inverse relation of organic acids to quality.

The data in Tables XXXI and XXXII show the tobaccos of grade 1 have the largest content of total soluble ash and content of calcium, potassium, and magnesium. The soils of these regions are low in content of available phosphorus, as shown in Chapter VIII, and sulphur, and

TABLE XXX. CHEMICAL COMPOSITION OF VARIETIES OF TURKISH TOBACCO
(percentage of dry weight)

Variety	*Nicotine*		*Total nitrogen*		*Albuminoid nitrogen*		*Protein*	
Artvin[1]	1.55		—		1.17		7.35	
Trabzon[1]	4.50		—		1.51		10.24	
	min.	*max.*	*min.*	*max.*	*min.*	*max.*	*min.*	*max.*
Samsun	0.12	1.13	1.72	3.21	1.32	1.79	8.23	11.20
Bafra	0.33	2.27	1.83	4.32	1.34	2.37	8.41	14.88
Tachova	0.31	2.25	1.83	2.79	1.00	1.57	6.26	9.72
Izmit	0.42	2.09	2.05	3.84	1.26	2.15	7.38	13.44
Duzçe-Hendek	0.42	3.17	1.80	3.21	1.17	1.95	7.35	12.17
Brusa	0.57	2.62	1.82	3.18	1.23	1.99	7.70	12.44
Aegean varieties	0.30	1.32	1.13	2.76	0.83	1.75	5.25	10.94
Malatya and Bitlis	1.65	5.35	1.36	4.48	0.91	1.88	5.52	11.73

[1] Average composition.

high in iron and aluminum, which may explain the low content of these elements in comparison with that of other types of tobacco. The rather high content of chlorine may be attributable to the use of goat and sheep manure used as fertilizer in the Near East. One of the outstanding features of the ash content among these tobaccos is the magnitude of the differences. The percentage of soluble ash is seen to range from 9.30 to 16.74; of silica, from 0.47 to 3.12; of calcium oxide, from 2.74 to 6.37; of magnesium oxide, from 0.61 to 1.26; of potassium oxide, from 1.96 to 5.00; of the oxides of iron and aluminum, from 0.34 to 1.37; of P_2O_5, from 0.44 to 0.96; of chlorine, from 0.15 to 1.34; and of sulphur, from 0.20 to 0.58.

Relatively few data on chemical analyses of aromatic tobaccos grown in the United States are available. Unpublished data by Moffett (1942) involve the results of determinations of the major constituents of four varieties. His results are assembled in Table XXXIII.

The outstanding features of the data in Table XXXIII are the relatively low percentages of carbohydrates and nitrogenous materials. These matters are brought into focus in a study by Wolford (1948) based on analyses involving the changes that occur during fermentation. He analyzed domestically grown and imported Samsun and Smyrna tobaccos, with the results shown in Table XXXIV.

Since these are two different types of aromatic tobaccos it is not apparent what significance should be attached to the differences shown by the data in the foregoing table. The magnitude of these differences

TABLE XXX. *(continued)*

Reducing substances		*Carbohydrates*		*Polyphenols*		*Resins*		*Ash*	
3.48 12.37		2.32 7.62		0.62 7.27		3.93 6.60		12.96 17.44	
min.	*max.*	*min.*	*max.*	*min.*	*max.*	*min.*	*max.*	*min.*	*max.*
4.48	16.32	3.14	12.83	0 20	4.47	2.69	5.95	11.25	16.00
1.67	12.21	0.24	8.73	0.05	4.66	4.11	4.91	12.45	18.10
5.45	16.10	3.75	14.10	1.11	4.57	2.89	8.93	13.00	17.34
0.73	11.92	1.89	9.98	0.12	4.41	3.12	7.69	13.81	18.77
1.00	12.03	0.23	9.80	0.27	4.71	3.87	8.01	11.78	17.08
2.87	15.40	2.32	11.27	0.31	4.82	4.37	9.07	13.25	19.00
8.36	22.40	7.08	17.97	0.71	6.99	4.60	7.78	11.64	18.77
0.21	24.03	0.16	19.40	0.05	4.63	44.21	10.44	11.10	19.80

TABLE XXXI. CHEMICAL COMPOSITION OF TOBACCOS GROWN IN GREECE

(percentage of dry weight[1])

Area	*Grade*	*Crop*	*Total N*	*Protein N*	*Nicotine*	*Petroleum Ether Extract*	*Starch*	*Reducing sugar*	*Total sugar*	*Total reducing substances*
Eastern Greece Region (Macedona and Thrace)										
Zihna	1	1937	2.15	0.96	0.87	6.11	4.66	11.85	12.33	14.47
		1938	2.31	0.96	1.04	4.56	4.28	12.73	14.55	15.08
	2	1937	2.54	0.94	1.70	6.86	2.17	9.63	10.05	11.86
		1938	2.53	0.91	1.68	6.39	2.65	9.85	10.61	12.78
	3	1937	2.83	1.05	1.65	6.55	1.66	6.99	7.55	8.54
		1938	2.55	0.96	1.34	5.40	3.08	11.23	12.07	12.95
Prav	1	1937	2.36	1.11	0.93	5.88	5.01	12.79	13.21	16.35
		1938	2.76	1.17	1.39	4.40	4.26	11.68	13.05	14.14
	2	1937	2.56	1.06	1.49	7.04	4.77	11.46	12.22	14.17
		1938	2.92	1.19	1.51	7.25	2.90	10.50	11.52	12.67
	3	1937	2.69	1.05	1.18	6.92	3.19	9.43	9.90	11.59
		1938	3.36	1.39	1.61	5.67	2.65	8.52	9.38	10.07
Serres	1	1937	2.52	1.00	1.64	6.79	3.33	7.89	8.30	10.25
		1938	2.39	0.95	1.43	4.13	4.20	11.37	12.92	13.47
	2	1937	2.85	0.95	2.17	7.52	2.05	6.19	6.52	7.21
		1938	2.63	0.92	2.23	7.13	2.78	8.39	9.09	11.13
	3	1937	2.92	0.98	2.27	7.39	1.77	4.40	4.82	5.32
		1938	2.80	1.02	2.26	6.18	2.83	7.99	8.61	9.68
Drama	1	1937	2.58	1.11	1.69	6.58	3.75	7.37	7.96	10.00
		1938	2.64	0.99	2.08	5.38	2.74	8.48	9.84	10.63
	2	1937	2.58	1.02	1.77	8.31	2.90	6.19	6.86	7.80
		1938	2.72	1.04	1.98	7.21	2.05	8.69	9.06	10.71
	3	1937	2.79	1.06	1.81	7.12	2.03	4.73	5.08	6.04
		1938	2.83	1.10	2.16	7.24	2.54	7.71	8.06	9.19
Djebel	1	1937	1.88	0.87	0.48	4.24	6.48	18.83	19.13	21.48
		1938	1.92	0.90	0.45	3.69	5.94	17.90	18.25	20.00
	2	1937	2.10	0.93	0.82	4.94	6.20	15.62	16.81	17.24
		1938	2.67	1.11	0.94	5.82	4.81	12.38	13.15	15.07
	3	1937	2.44	1.07	0.98	5.07	4.64	11.15	12.16	13.73
		1938	3.41	1.30	1.32	6.12	3.07	6.90	7.37	8.60
Souyalissi	1	1937	1.96	0.96	0.47	5.58	3.94	16.95	17.64	19.69
		1938	2.33	1.08	0.62	4.30	6.11	16.89	17.42	20.89
	2	1937	1.98	0.90	0.61	4.39	5.30	17.75	18.32	20.58
		1938	2.69	0.96	0.85	5.48	4.21	13.32	14.95	16.57
	3	1937	2.29	1.04	0.61	4.95	4.94	14.80	15.38	16.84
		1938	3.02	1.18	0.95	5.21	2.59	10.71	11.02	13.05
Xanthi (2nd Yaka)	1	1937	2.62	1.20	1.19	5.82	5.44	11.33	11.66	13.74
		1938	2.72	1.14	1.11	5.53	3.39	9.14	9.79	13.28
	2	1937	2.90	1.13	1.74	8.76	3.67	7.98	8.31	10.73
		1938	2.95	1.03	1.53	7.65	2.16	8.29	8.70	10.33
	3	1937	3.26	1.23	1.71	7.72	3.25	6.08	6.51	7.88
		1938	3.32	1.18	2.01	7.96	1.63	5.47	5.72	6.67
Komotini	1	1937	2.29	1.08	0.93	5.57	4.90	12.06	12.45	13.84
		1938	1.87	0.92	0.47	2.82	7.31	18.50	19.48	20.92
	2	1937	2.44	0.99	1.46	7.40	5.78	12.83	13.43	14.93
		1938	2.35	0.97	1.04	6.41	3.61	12.27	12.82	15.19
	3	1937	2.84	1.11	1.43	7.72	2.45	6.78	7.28	8.05
		1938	2.50	1.01	1.22	6.70	3.21	10.17	10.64	12.54
Proseçan	1	1938	2.31	0.98	1.02	5.33	4.52	13.09	14.42	16.36
	2	1938	2.61	0.90	1.50	7.23	2.29	9.60	10.31	11.04
	3	1938	2.67	1.02	1.34	6.31	2.72	9.10	9.60	10.70
Western Greece Region										
Agrinion	1	1937	2.01	0.81	1.33	5.23	4.00	11.10	11.73	14.27
		1938	2.05	0.94	1.28	4.59	5.56	11.42	12.26	13.46
	2	1937	2.08	0.92	1.06	7.16	4.26	11.38	12.26	13.63
		1938	2.04	0.87	1.20	6.38	4.06	12.89	14.73	15.11
	3	1937	2.37	1.04	1.51	7.07	3.75	9.67	10.64	11.44
		1938	2.24	0.98	1.49	6.47	4.55	10.96	11.68	12.86

TABLE XXXI. *(continued)*

Polyphenols	*Total acids*[1]	*H ion concn. (pH)*	*Hygroscopicity*	*Total soluble ash*	*SiO_2*	*CaO*	*MgO*	*K_2O*	*$Fe_2O_3 + Al_2O_3$*	*P_2O_5*	*Cl_2*	*S*
2.62	20.85	4.80	13.65	10.95	1.52	5.45	0.65	2.02	0.45	0.52	0.81	0.51
2.35	20.37	4.86	12.85	11.25	1.50	4.89	0.69	2.51	0.64	0.55	0.60	0.42
2.23	25.37	4.80	15.47	11.59	0.92	5.38	0.73	2.36	0.55	0.58	0.62	0.40
2.93	25.73	4.95	13.49	14.66	1.24	6.05	0.69	2.73	0.48	0.54	0.43	0.45
1.55	27.09	4.98	15.36	13.02	0.83	5.33	0.71	2.42	0.61	0.55	0.50	0.46
1.72	24.48	4.93	14.91	14.28	1.26	5.97	0.78	2.33	0.50	0.51	0.63	0.42
3.56	18.84	4.61	14.82	9.94	1.43	3.75	0.93	2.44	0.43	0.64	0.89	0.47
2.46	19.11	4.61	13.06	11.08	1.68	3.51	0.88	2.85	0.73	0.69	1.00	0.38
2.71	21.83	4.60	14.72	10.25	0.71	3.82	0.75	2.93	0.49	0.72	0.67	0.42
2.17	22.34	4.66	12.86	11.54	1.08	3.95	0.87	2.54	0.66	0.69	0.75	0.34
2.16	22.93	4.75	16.00	11.79	0.88	4.39	0.97	3.01	0.50	0.66	0.82	0.38
1.55	22.44	4.70	12.41	12.09	1.25	4.46	1.06	2.63	0.56	0.66	0.82	0.36
2.36	23.12	4.91	13.18	12.47	2.08	5.38	0.78	2.31	0.97	0.55	0.71	0.39
2.10	22.80	4.78	13.15	11.61	1.55	5.24	0.85	2.41	0.69	0.51	0.77	0.42
1.02	23.65	4.92	14.04	12.85	1.61	5.48	0.79	2.90	0.77	0.62	0.69	0.49
2.74	21.28	4.85	12.66	15.51	1.20	5.80	1.03	2.14	0.70	0.51	0.81	0.44
0.92	26.88	5.01	13.31	13.98	1.24	5.84	0.82	2.53	0.99	0.59	0.80	0.42
1.69	22.01	4.90	12.82	16.41	1.24	6.37	1.01	2.70	0.74	0.51	0.81	0.39
2.63	22.17	4.74	13.76	12.14	1.69	4.62	0.90	2.45	0.66	0.72	1.13	0.37
2.15	25.01	4.79	13.50	12.55	0.95	5.61	0.90	2.70	0.82	0.60	0.89	0.40
1.61	20.76	4.77	14.39	11.54	0.92	4.59	0.79	2.61	0.52	0.77	0.80	0.37
2.02	19.81	4.78	14.14	13.37	1.41	5.22	0.85	2.59	0.71	0.57	0.98	0.36
1.31	25.91	4.99	14.15	13.80	1.22	5.59	1.02	2.96	0.69	0.70	0.83	0.38
1.48	24.21	4.81	12.65	14.46	1.69	5.43	0.93	2.23	0.90	0.60	0.83	0.36
2.65	17.08	4.65	16.38	10.04	1.74	2.74	0.65	2.97	0.49	0.65	0.50	0.51
2.10	18.20	4.60	15.30	9.85	1.32	3.20	0.88	2.33	0.59	0.64	0.76	0.39
1.62	16.22	4.67	14.83	11.84	0.55	3.32	0.74	2.85	2.50	0.66	0.63	0.41
2.69	19.58	4.58	14.91	11.28	1.17	3.33	0.89	2.61	0.49	0.65	0.74	0.50
2.58	18.79	4.87	13.70	12.02	0.66	4.13	0.90	3.84	0.49	0.65	0.67	0.58
1.70	21.96	4.81	15.09	15.29	1.45	4.42	1.19	3.49	0.71	0.68	1.17	0.50
2.74	15.95	4.60	16.01	10.00	1.81	2.91	0.78	2.10	0.48	0.68	0.85	0.47
4.00	16.92	4.52	15.00	9.99	1.63	2.86	0.80	2.82	0.50	0.65	0.77	0.42
2.83	16.12	4.62	14.21	11.00	0.47	3.13	0.61	3.02	0.34	0.70	0.52	0.40
3.25	20.22	4.59	17.35	11.90	1.16	3.17	0.85	2.81	0.74	0.70	0.63	0.34
2.04	15.80	4.69	13.58	11.82	0.66	3.19	0.75	3.09	0.45	0.70	0.65	0.52
2.34	19.92	4.72	17.73	14.25	1.24	4.24	0.97	2.85	0.65	0.65	0.83	0.42
2.41	19.80	4.72	14.80	11.18	1.93	4.84	0.89	2.45	0.77	0.52	1.10	0.39
4.14	20.87	4.59	13.27	11.98	1.75	4.01	1.08	2.82	0.83	0.65	1.34	0.45
2.75	19.20	4.67	12.21	11.59	1.09	4.30	0.90	3.12	0.75	0.58	0.81	0.37
2.04	19.87	4.60	16.71	13.99	1.18	4.59	1.21	3.06	0.75	0.54	1.34	0.41
1.80	22.84	4.83	15.48	13.41	1.12	5.38	1.00	3.12	0.54	0.59	1.01	0.46
1.20	24.21	4.90	16.02	16.47	1.30	4.88	1.13	3.11	0.88	0.59	1.13	0.47
1.78	20.00	4.62	14.36	11.50	2.23	3.79	1.00	2.17	0.75	0.58	1.10	0.37
2.42	17.79	4.69	15.25	9.30	1.29	3.45	0.63	2.31	0.40	0.67	0.54	0.31
2.10	17.91	4.69	17.25	10.63	0.79	3.65	0.87	2.71	0.53	0.72	0.70	0.33
2.92	18.31	4.60	14.74	13.27	1.46	3.83	1.10	2.56	0.72	0.56	1.12	0.46
1.27	24.47	4.89	16.65	14.35	1.20	4.84	1.11	3.41	0.88	0.64	0.99	0.42
2.37	20.31	4.80	14.76	15.46	1.73	4.40	1.14	3.33	0.78	0.66	1.12	0.47
3.27	20.06	4.52	13.80	11.75	0.71	4.99	0.75	2.40	0.77	0.61	0.60	0.41
1.44	23.26	4.82	15.99	13.94	1.00	5.03	0.79	2.97	0.60	0.62	0.36	0.48
1.60	24.70	4.90	15.95	14.96	1.14	5.68	0.96	2.64	0.70	0.52	0.54	0.45
3.17	21.81	4.99	15.22	14.95	1.08	4.40	0.63	3.79	0.42	0.51	0.83	0.58
2.04	19.20	4.89	14.77	11.77	0.72	4.82	0.75	3.00	0.61	0.52	0.94	0.42
2.25	17.85	4.81	15.06	13.70	1.05	4.10	0.70	2.95	0.39	0.54	0.78	0.43
2.22	18.89	4.93	17.47	13.67	0.94	4.05	0.72	3.14	0.50	0.50	0.78	0.41
1.77	20.46	4.90	14.49	12.58	1.23	4.53	0.74	3.07	0.49	0.50	0.77	0.39
1.90	22.12	5.00	16.73	15.43	1.21	4.67	0.82	3.07	0.80	0.46	0.84	0.46

[1] Total acids expressed as cc. of 0.1 *N* alkali required to neutralize the acid in 1 gram of tobacco.

TABLE XXXII. CHEMICAL COMPOSITION OF TOBACCOS GROWN IN TURKEY

(percentage of dry weight[1])

Location	Grade	Crop	Total N	Protein N	Nicotine	Petroleum Ether Extract	Starch	Reducing sugar	Total sugar	Total reducing substances
Samsun Region										
Carick	1	1937	2.53	1.06	0.70	4.65	3.87	6.22	7.48	8.05
		1938	2.62	1.06	0.76	3.95	2.77	5.13	5.56	7.82
	2	1937	2.55	1.04	0.90	4.85	3.24	6.34	6.66	8.09
		1938	2.66	1.05	0.90	5.27	2.51	4.13	5.62	5.47
	3	1937	2.92	1.21	0.67	4.40	3.43	5.11	5.32	6.93
		1938	2.97	1.24	0.83	5.28	2.39	3.83	4.23	5.09
Bafra	1	1937	2.82	0.98	1.32	5.48	3.19	5.86	7.05	7.21
		1938	2.75	1.05	1.11	4.28	2.68	4.79	5.31	6.77
	2	1937	2.98	1.03	1.50	5.34	2.73	4.36	4.75	5.83
		1938	2.69	0.95	1.52	5.41	2.96	5.58	6.24	7.59
	3	1937	3.08	1.09	1.49	4.53	3.27	5.34	5.57	6.60
		1938	3.28	1.20	1.55	4.91	2.38	3.71	4.13	5.06
Maden	1	1937	2.84	1.03	1.31	4.83	3.73	5.65	6.31	6.99
		1938	2.81	1.03	1.16	4.96	2.79	4.81	5.61	6.75
	2	1937	2.83	1.02	1.48	6.20	2.99	5.08	5.33	7.55
		1938	2.73	0.94	1.47	5.19	2.89	5.95	6.73	7.98
	3	1937	3.35	1.31	1.47	5.43	1.94	3.99	4.31	5.82
		1938	3.05	1.22	1.50	5.08	2.51	3.97	4.73	5.38
Evkav	1	1937	2.74	0.99	1.54	5.22	3.36	5.84	6.51	7.76
		1938	2.92	1.02	1.33	4.62	2.70	4.63	5.20	6.54
	2	1937	2.81	0.97	1.72	6.45	2.86	4.74	5.11	5.94
		1938	2.99	0.99	1.40	5.68	2.24	4.80	5.44	6.47
	3	1937	3.10	1.15	1.57	5.55	2.85	4.80	5.23	6.34
		1938	3.43	1.22	1.73	5.63	2.15	2.93	3.12	4.56
Smyrna Region										
Akhisar	1	1937	1.52	0.84	0.88	5.29	9.28	13.58	13.81	15.85
		1938	1.50	0.81	0.75	3.99	6.84	15.56	16.92	19.01
	2	1937	1.63	0.81	0.98	5.45	7.25	14.56	15.75	16.02
		1938	1.50	0.75	0.77	5.29	6.01	16.58	17.42	19.91
	3	1937	1.83	0.96	1.13	5.92	7.41	11.89	12.41	13.18
		1938	1.67	0.88	0.90	4.83	5.29	12.21	13.68	15.09
Izmir	1	1937	1.72	0.92	1.04	4.87	7.37	13.94	14.31	16.37
		1938	1.61	0.85	0.83	4.20	5.63	16.03	16.57	18.17
	2	1937	1.72	0.83	1.21	5.64	6.88	14.45	15.54	16.53
		1938	1.69	0.82	1.01	5.31	5.66	14.75	15.76	17.34
	3	1937	2.00	0.99	1.29	6.15	6.62	12.88	13.41	14.74
		1938	1.86	0.97	1.08	5.58	4.89	12.34	13.15	15.05
Foca	1	1937	1.59	0.84	1.00	6.46	8.31	14.28	14.85	17.23
		1938	1.65	0.84	0.91	4.92	6.20	14.23	14.74	15.61
	2	1937	1.64	0.83	1.06	6.82	8.51	13.35	14.82	15.01
		1938	1.63	0.81	1.01	5.64	6.06	14.96	16.13	17.97
	3	1937	1.91	0.96	1.24	6.21	7.11	11.41	12.12	12.77
		1938	1.90	0.96	1.12	5.77	4.45	15.38	16.33	17.55
Muğla	1	1937	1.51	0.83	0.78	5.31	8.69	14.41	14.87	17.56
		1938	1.44	0.79	0.57	3.45	7.48	16.90	17.49	18.78
	2	1937	1.56	0.81	0.78	5.92	8.55	15.30	15.95	16.76
		1938	1.51	0.78	0.74	5.52	6.18	15.68	16.27	18.14
	3	1937	1.88	0.97	1.04	5.48	7.62	11.22	12.28	12.56
		1938	1.74	0.92	0.76	5.67	5.66	12.28	13.31	14.87

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[1] Expressed as cc. of 0.1 *N* alkali required to neutralize the acid in 1 gram of tobacco.

TABLE XXXII. *(continued)*

Poly-phe-nols	Total acids[1]	pH	Hygro-scopic-ity	Total solu-ble ash	SiO_2	CaO	MgO	K_2O	Fe_2O_3 + Al_2O_3	P_2O_5	Cl_2	S
1.83	21.63	4.83	15.05	12.21	1.48	3.32	0.96	4.03	0.82	0.81	0.68	0.40
2.69	25.50	4.99	14.58	14.08	1.44	4.19	1.00	4.09	0.59	0.76	0.65	0.33
1.75	21.61	4.86	14.71	15.39	1.19	3.73	1.01	4.07	0.60	0.87	0.59	0.33
1.34	24.98	5.07	14.12	15.22	1.23	4.60	1.13	3.86	0.62	0.77	0.54	0.36
1.82	22.51	4.99	14.55	16.74	1.60	4.35	1.20	4.05	0.92	0.86	0.78	0.35
1.26	23.37	5.13	13.72	15.48	1.16	4.65	1.26	5.00	0.55	0.77	0.71	0.38
1.35	24.36	4.76	15.58	12.18	1.38	3.74	0.91	3.59	0.44	0.70	0.66	0.43
1.98	22.80	4.88	13.85	13.23	1.23	3.83	1.07	4.21	0.51	0.76	0.36	0.44
1.47	26.16	4.79	14.82	14.50	0.91	4.38	0.92	4.07	0.40	0.77	0.55	0.40
2.01	24.09	4.90	13.12	13.54	1.47	5.04	1.00	3.69	0.54	0.71	0.42	0.40
1.26	21.86	4.82	14.87	13.72	0.91	4.40	1.03	3.47	0.38	0.77	0.83	0.44
1.35	25.16	4.93	12.86	14.36	1.81	4.36	1.15	3.48	0.74	0.68	0.72	0.43
1.34	22.77	4.80	14.13	11.94	1.45	3.77	1.00	3.40	0.64	0.68	0.76	0.41
1.94	23.89	4.89	14.05	13.48	1.41	4.21	1.13	4.18	0.69	0.66	0.62	0.39
2.47	23.31	4.90	14.99	13.93	0.71	4.18	1.23	3.78	0.64	0.96	0.70	0.38
2.03	24.29	4.89	13.54	13.67	1.65	4.38	1.22	4.01	0.69	0.70	0.46	0.40
1.83	23.25	4.82	14.73	13.37	1.05	4.43	1.37	3.49	0.68	0.80	0.85	0.38
1.41	23.81	4.90	13.06	14.44	1.92	4.85	1.24	3.43	0.86	0.74	0.63	0.44
1.92	23.74	4.80	13.83	12.34	1.89	4.22	0.89	3.32	0.57	0.63	0.62	0.49
1.91	25.70	4.85	13.20	13.23	1.53	4.13	1.00	4.13	0.74	0.67	0.62	0.43
1.20	23.03	4.80	13.30	13.32	1.07	4.60	0.89	3.58	0.66	0.77	0.42	0.44
1.67	25.05	4.93	13.48	13.81	1.18	4.52	1.19	3.95	0.58	0.81	0.47	0.36
1.54	22.45	4.80	13.36	13.95	1.25	4.72	1.17	3.50	1.01	0.77	0.72	0.42
1.63	25.41	5.10	13.40	14.96	1.85	4.48	1.22	3.96	0.87	0.69	0.71	0.42
2.27	19.17	5.09	14.40	12.01	2.51	3.69	0.95	2.82	0.85	0.59	0.48	0.36
3.45	22.11	5.23	13.67	12.42	1.33	4.25	0.84	3.12	0.81	0.51	0.16	0.35
1.46	19.09	5.00	14.85	12.57	2.80	4.25	0.83	3.62	1.08	0.52	0.29	0.34
3.33	18.71	5.10	13.95	12.57	2.70	4.02	0.76	2.82	0.72	0.60	0.15	0.25
1.29	19.46	5.01	13.66	13.38	2.11	5.55	1.14	2.59	1.22	0.54	0.52	0.34
2.88	17.28	5.13	13.00	13.93	3.12	4.25	1.01	2.88	0.99	0.58	0.26	0.37
2.43	18.33	5.11	14.68	11.76	2.75	4.16	0.79	2.25	0.83	0.48	1.00	0.39
2.14	16.30	5.10	14.29	12.48	2.55	4.03	0.75	2.91	1.17	0.47	0.56	0.35
2.08	17.97	5.01	13.85	12.26	1.49	4.62	0.76	2.55	1.01	0.54	0.62	0.31
2.59	20.76	4.99	13.56	12.39	1.13	4.28	0.71	2.50	0.66	0.48	0.62	0.33
1.86	18.66	5.02	13.73	12.75	1.54	4.94	0.98	2.28	1.04	0.51	1.02	0.35
2.71	18.57	4.99	12.46	13.23	1.32	5.16	0.87	2.39	0.75	0.50	0.82	0.35
2.95	16.93	4.98	15.27	11.18	2.33	3.52	0.85	2.36	0.67	0.44	1.10	0.38
1.38	16.96	4.89	12.59	12.04	1.99	3.80	0.77	3.08	0.77	0.47	0.95	0.42
1.66	17.91	4.99	14.19	12.04	1.61	3.89	0.83	2.97	0.87	0.54	0.96	0.34
3.01	17.64	4.93	13.58	12.26	2.17	3.70	0.79	2.87	0.52	0.57	0.57	0.35
1.36	23.02	5.00	13.83	13.64	1.73	5.02	1.06	2.90	1.00	0.45	0.86	0.38
2.17	18.39	4.91	13.31	13.54	2.39	3.92	0.94	2.96	0.59	0.58	0.72	0.38
3.15	17.48	5.19	14.26	11.75	2.86	4.60	0.66	1.96	0.92	0.44	0.74	0.33
1.88	17.00	5.09	12.81	13.15	2.94	3.79	0.75	2.91	1.19	0.56	0.48	0.34
1.46	17.65	5.10	13.37	12.01	1.36	4.79	0.63	2.20	1.00	0.53	0.62	0.28
2.46	16.35	4.94	14.05	13.71	2.15	3.81	0.68	2.62	0.69	0.60	0.51	0.30
1.34	21.90	5.00	12.54	13.75	2.02	5.12	0.96	2.50	1.37	0.54	0.86	0.28
2.59	19.72	5.00	13.31	13.59	2.66	4.55	0.90	2.37	1.01	0.61	0.67	0.32

between imported and domestic tobacco of these two varieties might even suggest that more significance should be attached to similarities between them, when grown in different regions, than to dissimilarities. The same variety of tobacco when grown in different regions always yields leaf that is chemically different.

Spacing and chemical composition

It is a matter of common knowledge among growers of all types of tobacco that leaf size and quality (chemical composition) can be modified by spacing. Experiments to determine the best "between row" and "within row" spacings have been made in all regions where aro-

TABLE XXXIII. CHEMICAL COMPOSITION OF NORTH CAROLINA-GROWN AROMATIC VARIETIES OF TOBACCO *(percentage of dry weight)*

Substances	*Samsun*	*Smyrna*	*Hendek*	*Xanthi-Yaka*
Total nitrogen	2.41	2.07	2.41	2.32
Protein nitrogen	1.10	1.03	1.15	1.19
Water-soluble nitrogen	1.20	0.95	1.15	0.96
Amino nitrogen	0.46	0.37	0.43	0.41
Nicotine	0.91	0.53	0.75	0.52
Petroleum ether extractive	5.90	6.94	4.21	4.80
Total sugars	2.13	5.48	2.51	2.24
Reducing sugars	—	5.13	2.06	1.89
Starch	2.55	3.58	2.93	1.97
Total acids	15.56	17.49	17.61	18.70

TABLE XXXIV. COMPARISON OF THE CHEMICAL COMPOSITION OF NORTH-CAROLINA-GROWN AND TURKEY-GROWN SAMSUN AND SMYRNA TOBACCOS *(percentage of dry weight)*

Substances	*Samsun*		*Smyrna*	
	Imported	*Domestic*	*Imported*	*Domestic*
Total nitrogen	2.89	2.25	1.68	1.95
Protein nitrogen	1.08	1.01	0.87	0.91
Amino nitrogen	0.41	0.27	0.12	0.13
Nicotine	1.29	0.93	0.96	0.86
Petroleum ether extractive	5.13	5.47	5.41	6.36
pH[1]	4 90	4.44	5.04	4.30
Total sugars	5.48	3.23	14.91	8.13
Starch	2.36	2.63	6.83	3.98
Total carbohydrates	8.66	6.16	22.50	12.58

[1] Not a percentage.

matic tobaccos have been grown. Per-acre-yield, size of leaf, and empirical judgment of the quality of the cured leaf have served largely as the criteria for determining the optimum spacing interval. In some instances, however, attempts have been made to confirm and to supplement these criteria with the results of chemical analyses. Among such are the experiments of Vlădescu *et al.* (1936), using the Rumanian varieties, Molovata, Ghimpatzi, and Sătmărean. Certain of their data are presented in the table that follows.

The increase in total nitrogen is directly correlated with increase in spacing interval. There is also a definite trend toward increase in nicotine with increase in distance between plants. A basic study of spacing as related to the development of rates of roots to tops might disclose why oriental tobaccos are low in nicotine content. Close spacing may inhibit root development, hence decrease nicotine content because nearly all of the nicotine is elaborated in the roots. The lowermost leaves are noted to have the largest ash content, as is the case with other types of tobacco, but the data do not establish that spacing per se modifies ash content.

TABLE XXXV. EFFECT OF SPACING INTERVAL AND STALK POSITIONS OF RUMANIAN TOBACCO ON CONTENT OF NITROGEN (*a*), NICOTINE (*b*) AND ASH (*c*) *(percentage of dry weight)*

Stalk position	*30 x 10 cm.*			*40 x 20 cm.*			*50 x 25 cm.*			*60 x 30 cm.*			*80 x 40 cm.*		
	a	*b*	*c*	*a*	*b*	*c*	*a*	*b*	*c*	*a*	*b*	*c*	*a*	*b*	*c*
poală	1.31	—	24.35	1.91	—	21.50	1.83	—	21.08	2.04	—	24.44	2.07	—	24.49
mijloc 1	1.45	0.26	18.47	2.00	0.33	17.82	2.47	0.30	18.83	2.43	0.50	19.06	2.64	0.53	19.90
mijloc 2	1.83	0.16	15.80	2.57	0.35	16.06	2.95	0.37	17.11	2.78	0.43	17.72	2.87	0.54	17.87
Vârf	2.79	0.18	18.09	2.94	0.40	16.99	2.68	0.41	17.21	3.16	0.55	18.25	3.04	0.68	18.19

TABLE XXXVI. INFLUENCE OF SPACING ON SIZE OF LEAVES OF AROMATIC TOBACCOS

Spacing interval (inches)	*Average leaf area cm.^{2}*	
	Ayasolouk	*Brusa*
48 x 24	372.6	348.0
20 x 5½	148.8	187.9
20 x 3	89.9	90.5

The writer (Wolf, 1946) gave consideration to leaf size as modified by the spacing interval, using two varieties, Ayasolouk and Brusa. Certain of the results are shown in Table XXXVI.

The influence of competition among the plants spaced 48 × 24 inches apart was negligible and the leaf was quite unlike aromatic tobacco, having little to commend it except filling power. Competition among plants with the other two spacings was intense, and the leaf was of a quality which is characteristic of good aromatic tobacco. Both yield and quality can be impaired, however, by too close spacing. It is believed, moreover, that the optimum spacing interval in a given region depends upon several factors among which are the variety, the level of mineral nutrients available, soil type, and rainfall during the growing season.

Influence of time of planting

There is a best time of the year to plant aromatic tobacco just as is the case with every annual crop. This optimum time for each area has been determined largely by empirical procedures. In general, aromatic tobaccos of best yield and quality in the North Temperate Zone are planted as early as possible after the time when the last frost usually occurs. In the Tropics, or in areas characterized by two seasons, a rainy one and a dry one, the best time of planting appears to be near the close of the rainy season. Experimental data on the effects of time of planting on the chemical composition of the crop however are meager. Vlădescu, Dimofte, and Zaporojanu (1936) analyzed three varieties of Rumanian tobacco planted at four different dates. Their findings are shown in Table XXXVII.

On the basis of these three constituents alone it is not possible to judge which time of planting is best. But, undoubtedly, knowledge of prevailing weather throughout the period of growth would aid in interpreting these results. In some seasons the yield from the earliest plantings is inferior to that planted ten to fourteen days later. Lower yield, however, may not be directly correlated with poorer quality. However, the data show an increase in total nitrogen in all grades of leaf with increase in lateness of date of planting.

Throughout the Near East in a given locality an interval of four to six weeks between the earliest planting and the last one is not unusual. There the belief exists that best yields occur from crops transplanted

TABLE XXXVII. EFFECT OF TIME OF PLANTING ON THE CONTENT OF CERTAIN CHEMICAL CONSTITUENTS OF RUMANIAN TOBACCOS *(percentage of dry weight)*

Substances	*Priming*	*April 18*	*May 6*	*May 26*	*June 25*
Total nitrogen	*poală*	1.71	2.08	2.10	2.67
	mijloc 1	2.10	2.48	2.75	3.31
	mijloc 2	2.20	2.42	3.18	4.31
	vârf	2.36	2.61	3.57	5.46
Nicotine	*poală*	—	—	—	—
	mijloc 1	0.34	0.36	0.58	0.83
	mijloc 2	0.39	0.33	0.46	0.65
	vârf	0.47	0.37	0.48	0.86
Ash	*poală*	21.81	22.07	21.72	24.83
	mijloc 1	15.86	18.12	18.23	20.91
	mijloc 2	16.43	18.43	17.14	18.00
	vârf	16.76	17.81	16.69	15.46

near the middle of the transplanting season. In the southeastern United States however, the best crops are produced when transplanting is done early in the season.

Chemical composition and primings

Vlădescu and his associates (1936) were concerned not only with spacing as a factor in modifying the chemical composition of tobacco but also with the factor of differences among primings. Their results, assembled in Table XXXVIII, deal with three varieties; Molovata, Ghimpatzi, and Sătmărean.

TABLE XXXVIII. DIFFERENCES AMONG PRIMINGS IN CHEMICAL COMPOSITION OF THREE VARIETIES OF RUMANIAN TOBACCO *(percentage of dry weight)*

Variety	*Grade*	*Total nitrogen*	*Nicotine*	*Carbohydrates*	*Ash*
Molovata	*poală*	1.72	0.41	8.35	18.05
	mijloc 1	1.96	0.32	12.44	16.44
	mijloc 2	2.24	0.45	13.92	15.52
	mijloc 3	2.50	0.57	8.57	12.14
	vârf	2.58	0.65	8.04	13.87
Ghimpatzi	*poală*	1.93	0.59	7.14	20.16
	mijloc 1	2.52	0.47	9.47	18.11
	mijloc 2	2.71	0.66	7.33	15.43
	mijloc 3	2.98	0.98	6.29	13.85
	vârf	3.21	1.27	6.57	14.27
Sătmărean	*poală*	2.02	0.52	4.02	21.12
	mijloc 1	2.41	0.63	6.49	19.47
	mijloc 2	2.52	0.87	7.12	16.22
	mijloc 3	2.79	1.12	4.88	14.05
	vârf	3.05	1.05	4.41	14.89

TABLE XXXIX. EFFECT OF SPACING ON CHEMICAL COMPOSITION OF CERTAIN VARIETIES OF TURKISH TOBACCOS *(percentage of dry weight)*

Variety	*Spacing, cm.*	*Nicotine*	*Total nitrogen*	*Protein*	*Protein nitrogen*	*Ash*	*Carbo-hydrates*	*Poly-phenols*	*Resins*
Basma	35 x 10	1.25	1.96	7.92	1.22	16.13	14.53	2.84	7.77
	40 x 15	1.39	2.24	8.50	1.36	16.92	11.59	2.96	7.93
	45 x 20	1.44	2.46	9.55	1.53	17.06	6.12	3.63	7.73
Izmit	35 x 15	1.38	1.89	7.93	1.27	15.63	15.71	3.75	6.28
	40 x 15	1.52	1.96	8.19	1.31	16.19	14.80	3.21	6.02
	45 x 20	1.77	2.24	8.88	1.42	16.53	12.07	3.72	6.12
Hendek	40 x 15	0.94	2.02	8.29	1.33	18.27	7.66	3.22	6.79
	45 x 20	0.92	2.07	8.60	1.38	18.65	7.45	3.20	6.25
	60 x 25	1.33	2.36	8.76	1.40	19.66	7.13	3.33	6.33

Each of these varieties exhibits rather uniformly a decrease in total nitrogen with increase in quality but with ash an inverse relationship. The distribution of total nitrogen, nicotine, and ash among them presents consistent patterns in the light of analyses of other types of tobacco.

Erakman and Mühendisi (1951) made analyses of three differently spaced varieties of Turkish tobacco. Their findings are summarized in Table XXXIX.

The data, as regards nicotine, proteins, total nitrogen, and ash show consistent increases with increase in spacing interval, but this trend does not exist with content of carbohydrates, polyphenols, and resins.

Aksu and Enercan (1956) attempted to find an index of quality among Turkish varieties of tobacco based upon a relationship in percentage of nicotine and protein nitrogen to reducing substances. Their data are given in Table XL.

In determining the quality index they employed the percentage of reducing substances (carbohydrates and polyphenols) as the numerator

TABLE XL. AVERAGE CONTENT OF NICOTINE, PROTEIN NITROGEN, AND REDUCING SUBSTANCES IN CROPS OF TURKISH TOBACCO OF 1952 *(percentage of dry weight)*

Variety	*Nicotine*	*Protein nitrogen*	*Reducing substances*
Artvin	2.0	1.5	10.5
Trabzon	4.5	1.6	4.0
Samsun	1.5	1.6	10.0
Bafra	1.5	1.7	9.5
Toxat	1.1	1.4	18.0

and the percentage of protein nitrogen plus that of nicotine as the denominator. If the quotient exceeds 10 they regarded the tobacco as of good quality, and if less than 10, of poor quality.

Earlier these same investigators (Aksu and Enercan, 1954) had analyzed tobaccos of the 1951 crop from thirty-eight localities and of the 1952 crop from fifty-six localities. In relatively few cases, according to their quality index, were the tobaccos of superior quality. They noted that the reducing substances should exceed 15% and that the percentage of nicotine should be less than 1% and protein nitrogen less than 1.2%. Their data showed that only 39 of the 114 samples had a percentage of reducing substances in excess of 15%, and for this reason one is inclined to question the validity of this index of quality.

Nicotine content

Investigators have emphasized repeatedly that aromatic tobaccos are characterized by their low content of nicotine and that nicotine is correlated with mildness when the tobaccos are smoked. For this reason this alkaloid will be given brief consideration.

It may come as a surprise to many that nicotine is synthesized not only by the various species of *Nicotiana* but also by certain other kinds of seed plants. These other kinds include *Erythroxylum coca* Lam., *Sedum acre* L., *Asclepias syriaca* L., *Solanum melongena* L., *Petunia violacea* Lindl., *Datura stramonium* Thunb., *Lycopersicum esculentum* Mill., *Eclipta alba* Hassk., and *Zinnia elegans,* Jacq.

One of the earliest chemical studies dealing with nicotine was made by Vauquelin (1809). From both green and cured leaves of tobacco he isolated a colorless, bitter, water-soluble and alcohol-soluble principle that differed from all others occurring in plants. He did not identify it, however, but a few years later Hermstadt (1821; see Tiedemann p. 304) extracted a similar substance having the odor and taste of tobacco, and he called this white crystalline material nicotianin. Seven years later Posselt and Neimann (1828; see Tiedeman p. 305) distilled from green leaves and from dried leaves of tobacco a white, crystalline, fatty material, soluble in water, alcohol, and ether, a product like that called nicotianin by Hermstadt. They called this product nicotine. Their data showed that tobacco leaves, on a fresh weight basis, contained 1/1000% nicotine and on a dry weight basis 2/3% nicotine. They administered nicotine to rabbits and to dogs, finding that one-quarter drop and one to two drops were lethal to these two kinds of animals, respectively. An elemental analysis of nicotine was first made by Ortigosa (1842). By use of several methods of analyses he found that nicotine has a molecular weight of 1015.4 and the empirical formula $C_{10}H_{16}N_2$. This formula thus contains two hydrogen atoms in excess of that currently accepted as correct. It has been known, at least since 1843, that nicotine is present in tobacco smoke. In that year Melsens (1843) extracted nicotine from the smoke of Virginia tobacco being smoked in a pipe.

One of the most interesting findings regarding nicotine is that it does not occur uniformly in all parts of the leaf. Andreadis and Toole (1934, 1939) found that there is a pattern of distribution of nicotine in the leaves of certain varieties of Greek tobaccos. By dividing the leaf into segments and determining the nicotine content of such segments, they found that nicotine increases in amount from the base of the leaf toward the leaf tip and also from the midrib toward the margin. Lesser amounts occur also in the tissues midway between the lateral veins than in those near the veins. The amounts in tissues near the leaf tip and margins were approximately 100% more than in tissues near the base of the leaf near the midrib. These results were confirmed by Vlădescu and Dimofte (1939, 1941, 1942) using the variety Sătmă-

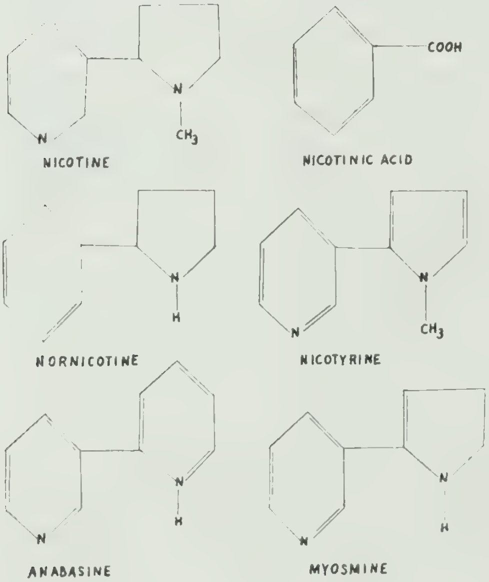

FIG. 89. Skeletal molecular structural of nicotine and related alkaloids in tobacco.

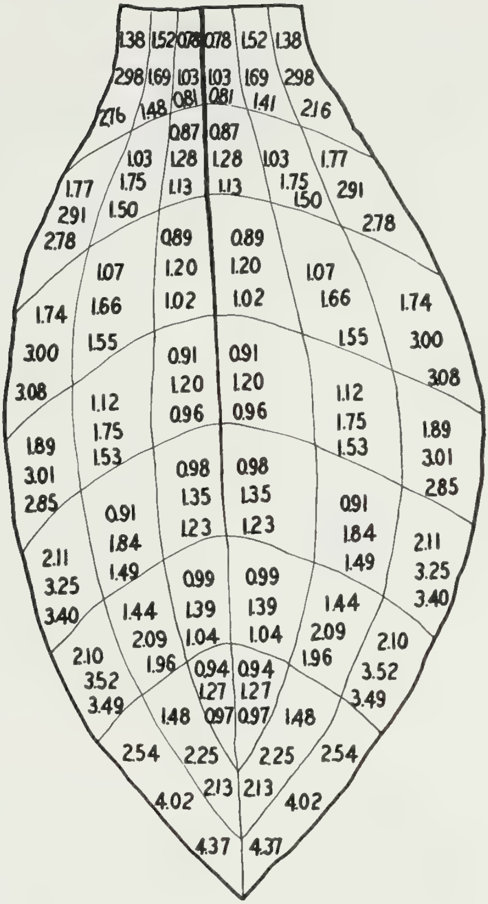

FIG. 90. Pattern of distribution of nicotine in Basma Serres tobacco leaf. Adapted from Andreadis (1939).

rean, a semi-oriental kind. They also found that other nitrogenous constituents and carbohydrates have a similar pattern of distribution.

Analyses of nicotine and resins in each of the crops grown in Turkey during the 1935-1938 period were made by Aksu (1951). His findings are summarized in Table XLI.

Even though the data are incomplete they show that the nicotine and resin contents differ among the varieties and within each one. It may be assumed that these differences are caused largely by weather differences among the seasons.

Andreadis and Toole (1933) determined the nicotine content of successive primings of several varieties of Xanthi. Their findings are shown in Table XLII.

These data are in accord among the different varieties in showing

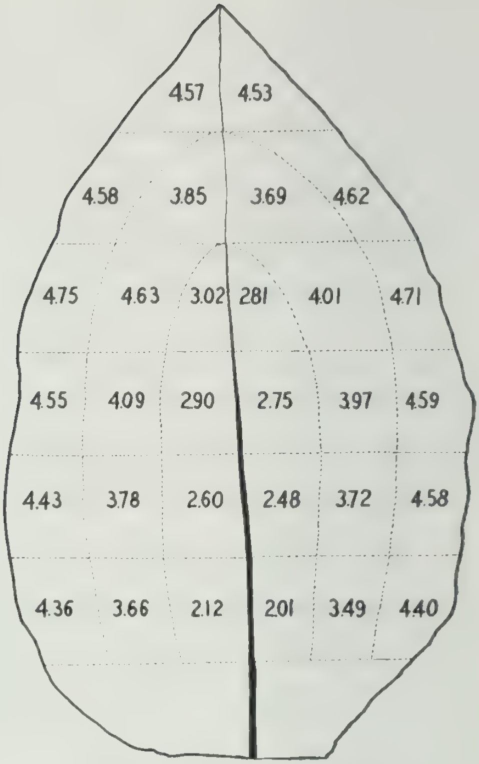

FIG. 91. Distributional pattern of nicotine in a leaf of the variety Sătmărean. Adapted from Vlădescu (1938).

that the nicotine content differs both according to the primings and to the varieties. The leaves borne near the midregion of the stalk have the larger percentage of nicotine with lesser amounts in the lower leaves and in the tips.

Nicotine content and environment—As is well known, both heredity and environment influence the nicotine content of tobacco. The re-

TABLE XLI. NICOTINE AND RESIN CONTENT OF CERTAIN VARIETIES OF TURKISH TOBACCO OF THE 1935-1938 CROPS *(percentage of dry weight)*

Variety	*1935*		*1936*		*1937*		*1938*	
	Nicotine	*Resin*	*Nicotine*	*Resin*	*Nicotine*	*Resin*	*Nicotine*	*Resin*
Izmir	0.78	5.42	0.50	6.29	0.94	5.91	0.70	5.63
Basma	1.03	5.44	0.72	4.60	—	—	0.61	3.95
Samsun	0.85	4.29	—	—	—	—	1.59	6.31
Maden	0.51	3.34	0.65	4.61	—	—	0.69	5.59
Bafra	1.11	4.88	0.97	5.76	0.85	5.27	0.78	5.65
Various Aegean varieties, average	0.72	—	0.47	—	0.90	—	0.56	—

TABLE XLII. NICOTINE CONTENT OF SUCCESSIVE PRIMINGS OF XANTHI VARIETIES
(percentage of dry weight)

Variety	Year	Priming							
		1	2	3	4	5	6	7	8
Yaka Xanthi (Axilar)	1930	1.02	1.33	2.14	1.54	1.00	0.92	—	—
Yaka Xanthi (Tikisli)	1930	1.00	1.15	2.10	2.17	1.54	1.33	—	—
Dzembeli Xanthi (Sechini)	1930	0.31	0.39	1.62	1.70	1.44	1.45	—	—
Basma Serrai (Institut)	1930	1.80	2.43	2.94	3.13	2.65	2.97	—	—
Bachi-Bagli Rawika (Institut)	1930	1.23	1.80	1.85	1.66	1.53	1.53	1.48	—
Basma Xanthi (Institut)	1931	1.58	1.60	2.50	1.82	1.58	1.45	1.61	1.77
Basma Machalades (Institut)	1931	1.64	1.44	1.65	1.81	1.47	1.52	1.60	1.59
Bachi-Bagli Rawika (Institut)	1931	2.05	2.47	3.09	2.76	2.03	1.85	—	—

sults of studies by Anitia and Ille (1958), dealing with differences among aromatic varieties grown in different localities in Rumania, are contained in Table XLIII.

It may be noted from the above data that in any given year there were differences in nicotine content among the several varieties. Also in some seasons the nicotine content of a given variety was found to be twice that of the content in other years.

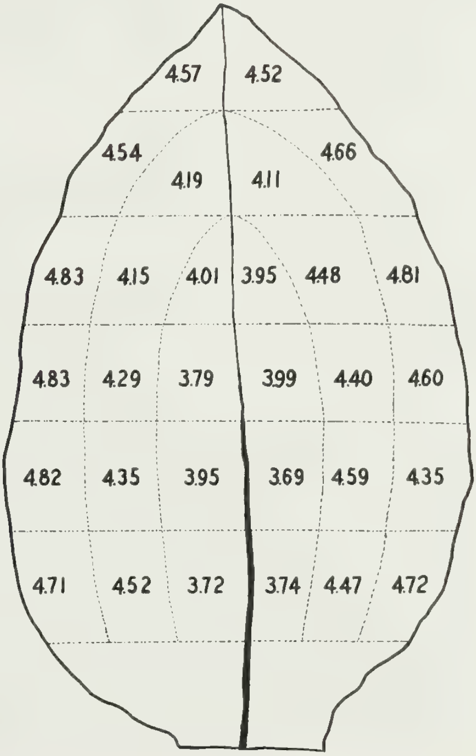

FIG. 92. Pattern showing distribution of total nitrogen, expressed as grams per 100 grams of dry substance, in leaf of the variety Sătmărean. Adapted from Vlădescu (1939).

TABLE XLIII. VARIATION IN NICOTINE CONTENT AMONG VARIETIES GROWN FOR A SERIES OF YEARS IN RUMANIA *(percentage of dry weight)*

Variety	*1952*	*1953*	*1954*	*1956*	*1957*	*Average*
Dragasani	1.29	1.06	0.97	0.83	0.55	0.94
Djebel	1.68	2.34	1.10	0.81	0.77	1.34
Perustitza	1.58	1.66	0.93	1.12	1.27	1.31
Molovata	1.69	1.43	0.87	0.75	0.97	1.14
Ghimpatzi	2.15	2.35	1.15	1.40	1.47	1.70
Beneasa 7	—	1.50	0.65	0.67	0.65	0.87
Ghimpatzi Lupu 357	2.06	1.86	1.07	1.15	1.25	1.48
Banat	1.73	1.94	1.00	1.34	1.18	1.44
Ialomitza	1.11	1.45	1.30	1.12	0.93	1.18

Resins, waxes, and ethereal oils

When one comes in contact with green leaves of tobacco a sticky, gummy substance adheres to one's hands and clothes. This substance is a complex of products secreted by the glandular hairs that occur at the surface of all above-ground parts of the plants. These excretions are of great importance, especially in oriental tobaccos, because they constitute the primary source of the characteristic aromas. Numerous investigators, among them Brückner (1936), Sabetay *et al.* (1941), Pyriki (1942, 1948), Smirnow *et al.* (1952), Bentley and Wolf (1945), and Wolf (1946), have directed attention to glandular hairs and the chemical nature of the secretions.

The hairs are organelles, each being tipped by a gland that is provided with chloroplasts, by virtue of which the secretions are elaborated within the gland. The secretions are extruded through the gland wall and accumulate as blebs beneath the cuticle. They are freed by the eventual rupture of the cuticle. Hot days with bright sunshine stimulate the production and excretion of these materials. During rainy weather the glands remain quite inactive and the exudate present is washed away.

It should be indicated that the chemical nature of these excretory products well merits much additional investigation because there is a direct correlation between the content of exudate and the quality of the tobacco, as stated by Brückner (1936): "Auf Grund der vorliegenden Untersuchungen kommen wir zu dem Ergebnis das der qualität des Tabaks, die bekanntlich nur aus dem Zusammenwirkung aller Tabakinshaltskörper restlos erklarbar ist, im allgemein in einen direkten Verhältnis zu seinem Hartzgehalt steht."* The early studies on tobacco resins, wax, and ethereal oils are summarized by Brückner, and are supplemented by his own findings. It is well established that these excretions consist of two complex groups of substances, waxes and resins, both of which can be extracted by steam distillation. The waxes are a complex mixture of aliphatic, aromatic, and hydroaromatic substances. The resins are high molecular polymers that are formed from ethereal oils by oxidation and condensation. When cleaved, the resins yield oils which possess characteristic aromas, ketones, esters, and various organic acids, the structures of which are quite unknown. The resins have been extracted with ethanol and fractionated. Pyriki (1948), using oriental tobaccos, separated from the resin fraction an average of 21.88% α-tobaccic acid, 4.05% β-tobaccic acid, 11.68% γ-tobaccic acid, and 0.68% resinol. There was a residue of 61.43%, a resene, which was a sticky, yellowish to brownish complex with a honey-like aroma. None of the acids had an odor characteristic of tobacco. The waxy component is soluble in hot ethanol but insoluble in cold ethanol, and according to Gladding and Wright (1959), consists essentially of two hydrocarbons, heptacosane, $C_{27}H_{56}$, and hentriacontane, $C_{31}H_{64}$, neither of which has aromatic properties. It appears that heptocosane, as identified, is a mixture of several hydrocarbons.

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* Freely translated: "On the basis of the foregoing experiments we may conclude that quality in tobacco, although it can only be finally explained on the basis of the interaction of all constituents, yet it stands, in general, in direct relation to resin content."

More recently Onishi *et al.* (1955-1957) made a series of studies

TABLE XLIV. RESIN AND WAX CONTENT (ALCOHOL EXTRACTIVE) OF SEVERAL VARIETIES OF ORIENTAL TOBACCO ***(percentage of dry weight)***

Variety	*Grade*	*Resins*	*Waxes*
Serres Demirhissar	I	10.34	0.50
Serres Demirhissar	IV	10.67	0.52
Kavala	I	11.63	0.52
Kavala	IV	9.82	0.48
Stanimaka	I	9.03	0.57
Stanimaka	III	7.93	0.55
Plovdiv-Yaka	I	10.22	0.73
Plovdiv-Yaka	III	10.57	0.74
Zichna	I-IV	10.44	0.46
Xanthi-Djebel		9.43	0.48
Pravista Paleochori	I-IV	10.22	0.45
Karadag	I-IV	8.85	0.43
Perustitza	I-IV	8.97	0.40
Melnik	I-V	7.11	0.31
Plovdiv-Yaka	I-V	7.59	0.48
Bulgarian Djebel	I-IV	9.02	0.44
Smyrna Giavourköy	I-IV	10.85	0.43
Smyrna Muğla	I-IV	10.93	0.43

of the "essential oils" of tobacco leaves by fractionating the constituent carbonyl compounds such as 2, 4-dinitrophenylhydrazone. He obtained therefrom acetaldehyde, isobutyraldehyde, benzaldehyde, acetone, furfurals, and valeraldehyde in differing amounts from different types of tobacco.

Pyriki (1948) extracted the resins and waxes from oriental tobaccos grown during the period 1938-1941 in Greece, Turkey, and Bulgaria and found that they contained the amounts shown in Table XLIV.

The resin content among varieties is seen to range widely. Differences of this magnitude undoubtedly are very significant for the reason that resins are complexes of odorous substances. Moreover, resin content is among the factors that govern combustibility. As for the significance of differences in amounts of waxes, too little is known about them to interpret these findings.

Polyphenolic constituents

Recent investigations of the chemistry of tobacco have been much concerned with polyphenolic constituents. Polyphenols are present in all types of tobacco, being more abundant in some types than in others. The status of current knowledge of this group of substances including caffetannins, coumarins, flavonoids, and certain simple phenolic derivatives as isolated from tobacco, has been summarized recently by Stedman (1957).

Apparently Shmuk (1927) and Shmuk and Semanova (1927) first directed attention to the fact that color and quality of aromatic tobacco are related to content of polyphenols. They maintained that the greater the polyphenol content, the greater the polyphenol coefficient, the darker the color of the leaf and the lower the quality. These findings stimulated Shmuk and his associates (Shmuk and Balabuscha-Popzowa (1927), Piatnicki (1929), Shmuk (1929), Shmuk (1930), Shmuk and Piatnicki (1930)) to make a series of studies involving not only polyphenols but various organic acids of tobacco. The analyses of Shmuk and Balabuscha-Popzowa (1927) of aromatic tobacco from Crimea, the Black Sea region, and Armenia showed that the better grades of tobacco had the greater content of polyphenols and carbohydrates and the lesser amounts of proteins and total nitrogen. Piatnicki (1929) found that low organic acid content is associated with good tobacco and high content with poor tobacco. Shmuk (1929) isolated from Trabzon tobacco acetic, formic, fumaric, malic, succinic, and an unidentified acid. Pjatnitskij (Piatnicki) (1935) found citric acid in green, dried, and fermented leaves of oriental tobaccos (Kuban and Maikop). Aksu and Kora (1949) found that citric, oxalic, and malic acids are not uniformly distributed within the leaves. It may be recalled that such other substances as nicotine, proteins, and carbohydrates had earlier been found to be present in larger amounts in certain regions of the leaf than in others.

Shmuk and Piatnicki (1930) isolated from fermented Samsun tobacco citric, caffeic, and probably also chlorogenic acid. Recently Mikhailov (1956) extracted Bulgarian tobaccos and chromatographed the extractive with the result that chlorogenic acid-like spots were present on the paper. He believed that geometric isomers of caffetannins were present. Meantime many investigators have given special attention to chlorogenic acid, and it is becoming one of the best known of the polyphenols. The accumulated evidence shows that it is a depside of caffeic and quinic acids. Studies show that chlorogenic acid and its isomers are oxidized and hydrolyzed by the action of certain enzymes during the curing and fermentation of tobacco. But according to Stedman (1957), current knowledge of the polyphenolic constituents of

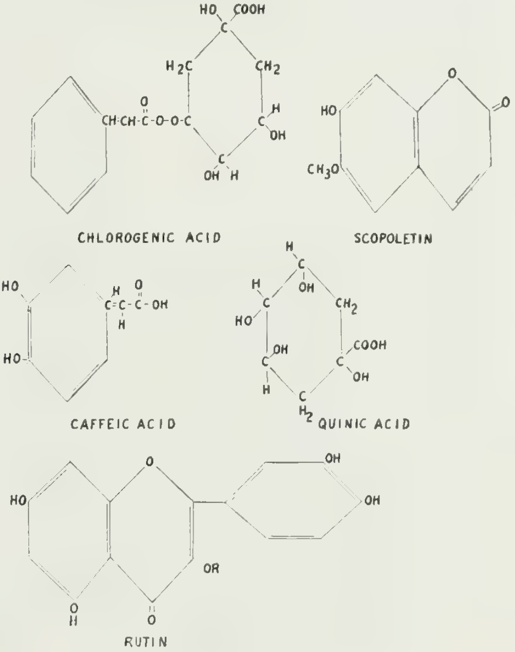

FIG. 93. Molecular structure of chlorogenic, caffeic, and quinic acids and of scopoletin and rutin.

tobacco remains fragmentary. He states that eugenol, guiacol, phenol, caffeic acid, and melilotic acid are among the identified derivatives, meso-inositol and quinic acid among the hydroxylated cyclohexanes, and that, in addition, there are approximately thirty other polyphenolic derivatives that have not yet been identified. Among the related groups are the flavonoids, rutin and isoquercitin, and among the coumarins is scopoletin.

Zucker and Ahrens (1958) noted that chlorogenic acid is not uniformly distributed within the leaf but occurs in increasing amount from the leaf base toward the tip. It is present in much lesser amounts in stem and root tissues.

Various other constituents in tobacco leaves and smoke

From fresh leaves, cured leaves, and tobacco smoke there have been isolated various hydrocarbons and organic acids in addition to those previously noted. Acetylene, butane, butadiene, ethane, ethylene, methane, propane, and propylene are among the volatile hydrocarbons that have been identified in the smoke. By means of ultraviolet spectroscopy such aromatic hydrocarbons as anthracene, pyrene, fluoranthene, and 3, 4-benzpyrene have been identified in extracts from fresh and cured leaves. Twenty-four amino acids are known to

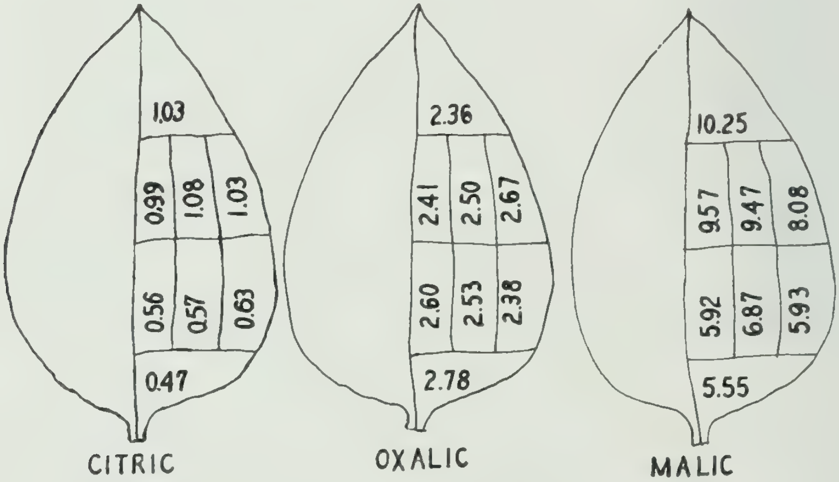

FIG. 94. Distribution of citric, malic, and oxalic acids in a Turkish tobacco leaf, as determined by Aksu and Kora (1949).

be constituents of tobacco proteins. Approximately 65% of tobacco leaf proteins consist of the amino acids, aspartic, glutamic, glycine, lycine, and leucine. During curing and fermentation these amino acids are liberated as products of protein breakdown. Other organic acids found both in leaves and tobacco smoke include arachidic, benzoic, caproic, isobutyric, isovaleric, lactic, lauric, linoleic, maleic, myristic, nicotinic, oleic, palmitic, propionic, stearic, and valeric.

Considerable attention has been given recently to the sterols of the tobacco leaf and smoke. The most important ones, identified by chromatographic techniques, are stigmasterol, β-sitosterol, and γ-sitosterol. Ergosterol has also been identified as a minor component among tobacco sterols. Flue-cured, Burley, and Maryland types are found to contain more sterol components than aromatic varieties. Because so much importance is attached to the color of cured tobacco many investigators have been concerned with leaf pigments. Nierenstein (1934) showed that they contain quercetin, rhamnetin, quercetagetin, and methyl-quercetagetin, and that the brown and yellow colors are due to the ratio of these pigments. More recently a brown pigment, rutin, and isoquercetin were isolated from Bulgarian tobacco (Mikhailov, 1956). Moreover,

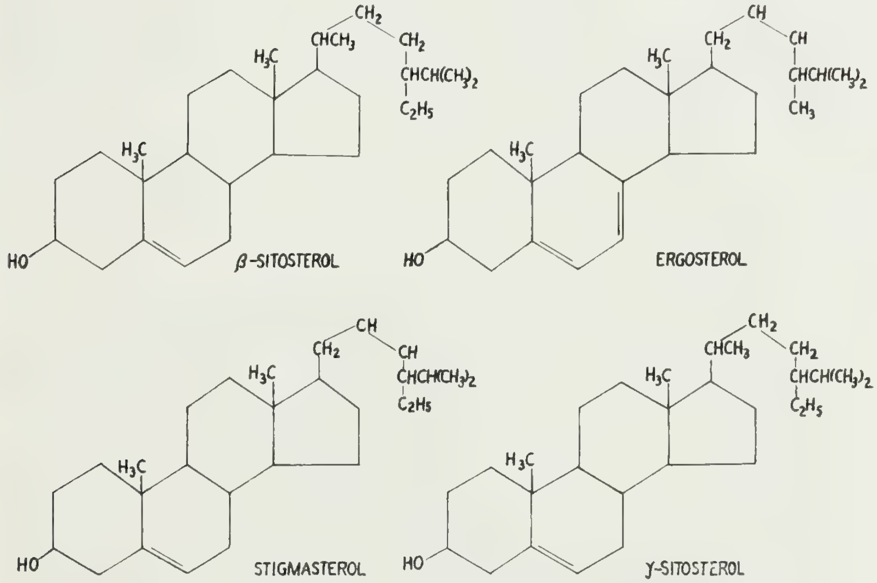

FIG. 95. Skeletal structure of certain sterols isolated from tobacco leaves.

the polyphenols acted upon by enzymes during curing and fermentation yield materials with brown colors. Green tobacco leaves are known to contain chlorophylls, carotenes, and xanthophylls that persist in appreciable quantities in the cured leaves.

Limited studies have been made of the pectic substances, the cell-wall materials that bind the cells to each other, among aromatic tobaccos. It appears, however, that the content of pectins is always greater in tobaccos of poor quality.

Ash content and combustibility

The importance of the ash content becomes apparent when it is appreciated that it is related to combustibility. Its amount is routinely measured whenever tobacco is analyzed. This fact has been amply demonstrated by the data previously presented in this chapter. The kind and amount of ash constituents are directly correlated with rate of burn. Wenusch (1937) found that the greater the content of ash the better the combustibility of certain varieties of aromatic tobacco. Rate of burn was tested by him by a method now widely employed, namely, by applying a glowing cigarette to the leaf to be tested. The perforation made by igniting the leaf in this way will continue to enlarge as burning proceeds. One can either measure elapsed time before burning ceases or else the diameter of the perforation formed to determine combustibility. The results of ash analyses obtained by Wenusch, arranged to show correlation between ash content and combustibility, are shown in Table XLV.

All other factors being regarded as equal, the kind with the greatest ash content was found to burn best. Potassium and its salts have been found to be especially favorable in promoting good burning quality, whereas chlorine is very deleterious.

TABLE XLV. ASH CONTENT AND COMBUSTIBILITY IN DESCENDING ORDER OF AROMATIC TOBACCO VARIETIES *(percentage of dry weight)*

Variety and grade	*Ash content*	*Variety and grade*	*Ash content*
Gümüldjina, I (Komotini)	16.5	Gümüldjina, IV	12.8
Nigrita, I	15.7	Tachova Nixar, 5 L. F.	12.6
Djebel-Basma, I	15.1	Djebel-Basma, V	12.2
Nigrita	14.1	Tachova-Nixar, IV	10 1
Brusa	14.0	Tachova Nixar N II	9 6
Djebel-Basma, V	13.4		

TABLE XLVI. ARSENICAL CONTENT OF AROMATIC TOBACCOS *(parts per million)*

Variety	*As_2O_3*	*Variety*	*As_2O_3*
Hendek	0.4	Evkav	0.3
Edirne	0.2	Bafra	0.6
Balikesir	0.4	Tachova	0.4
Izmir	0.6	Duzçe	0.3
Brusa	0.7	Trabzon	0.3
Çanik	0.2	Alaçam	0.4
Maden	0.4	Adiyaman	0.5

Arsenic content

Compounds of arsenic have been employed as dusts, sprays, and poisoned bait in the control of certain pests of tobacco, especially budworms, hornworms, wireworms, etc. It may be anticipated therefore that this element would be present in the soils of the fields in which this poison was applied and hence there exists the likelihood that it might be absorbed by succeeding crops. Several investigators, among them Aksu and Enercan (1954), have considered this possibility. They sampled a number of varieties of aromatic tobacco from the crops of 1949 and 1950, which apparently were sprayed with an arsenical, using a modified Gutzeit method, with the results shown in Table XLVI.

In addition, they sampled blended cigarettes and pipe tobaccos of several brands and found in all of them comparable amounts of arsenic. Special significance attaches to these findings because arsenic is known to be carcinogenic and a constituent of the smoke. Manifestly arsenicals should never be applied to tobacco as insecticides after it has been transplanted.

Composition of aromatic tobaccos in comparison with other types of cigarette tobaccos

The similarities and differences between aromatic tobacco and other types employed in the manufacture of cigarettes is best summarized by data from a report by Harlan and Moseley (1955). They used a mixture of aromatic kinds grown in three regions: Macedonia, Izmir, and Samsun. All samples of each type had been aged and their constituent percentages were calculated on a moisture-free basis. The results of their analyses are shown in Table XLVII.

In the first place, these data serve as an answer to the question that is repeatedly asked, "How do the different types of smoking tobaccos

TABLE XLVII. REPRESENTATIVE ANALYSES OF CIGARETTE TOBACCOS *(percentage of dry weight)*

	Types of tobacco			
Components	*Aromatic*	*Flue-cured*	*Burley*	*Maryland*
Total volatile bases, as ammonia	0.289	0.282	0.621	0.366
Nicotine	1.05	1.93	2.91	1.27
Ammonia	0.105	0.119	0.159	0.130
Glutamine, as ammonia	0.020	0.033	0.035	0.041
Asparagine, as ammonia	0.058	0.025	0.111	0.016
L-amino N., as ammonia	0.117	0.665	0.203	0.075
Protein N., as ammonia	1.19	0.91	1.77	1.61
Nitrate N., as NO_3	Trace	Trace	1.70	0.087
Total N., as ammonia	2.65	1.97	3.96	2.80
pH	4.90[1]	5.45[1]	5.80[1]	6.60[1]
Total vol. acids	0.194	0.153	0.105	0.090
Formic acid	0.079	0.059	0.027	0.022
Malic acid	3.87	2.83	6.75	2.43
Citric acid	1.03	0.78	8.22	2.98
Oxalic acid	3.16	0.81	3.04	2.79
Vol. oils	0.248	0.148	0.141	0.140
Alcohol-sol. resins	11.28	9.08	9.27	8.94
Red. sugars, as dextrose	12.39	22.09	0.21	0.21
Pectin, as calcium pectate	6.77	6.19	9.91	12.14
Crude fiber	6.63	7.88	9.29	21.79
Ash	14.78	10.81	24.53	21.98
Calcium, as CaO	4.22	2.22	8.01	4.79
Potassium, as K_2O	2.33	2.49	5.22	4.40
Magnesium, as MgO	0.69	0.36	1.29	1.03
Chlorine, as Cl	0.69	0.84	0.91	0.26
Phosphorus, as P_2O_5	0.47	0.51	0.57	0.53
Sulfur, as SO_4	1.40	1.23	1.98	3.34
Alkalinity of H_2O-sol. ash.	22.5[2]	15.9[2]	36.20[2]	36.90[2]

[1] Not a percentage. [2] Ml. of 1 N acid per 100 gm. tobacco.

differ chemically?" As one would anticipate from knowing the close genetic relationship of the several types, these representative data show that the types differ from each other, not in kinds of chemical components, but in amounts of constituents. It is evident from these data that aromatic tobaccos are markedly different from those of other types in that their nicotine content is lower, their content of resins and volatile oils is more abundant (the features that characterize them most conspicuously), their sugar content approximates half of that in flue-cured tobaccos, and their content of volatile acids exceeds that of other types. While the content of other components differ, these differences are less pronounced albeit they are differentially important.

Summary

Analytical data dealing with the principal chemical constituents occurring in aromatic tobaccos have been presented in tabular form. The data involve varieties grown in Turkey, Greece, Rumania, and the United States. They show differences among varieties when grown in the same region and when grown in different regions. They also show differences among grades and differences that may be attributed to seasons, to position on the stalk at which the leaves are borne, to time of planting, to spacing intervals, and to manipulative practices. Attempts have been made to interpret the data in a way to indicate that chemical composition of aromatic tobaccos is correlated with quality characteristics. As anticipated, aromatic tobaccos have been found to contain the same kinds of constituents, both organic and inorganic, as do all other types of tobacco, but the amounts and proportions of these components are characteristically different.

Attention is also directed to the occurrence in aromatic tobaccos of many compounds such as aldehydes, ketones, terpenes, resins, waxes, ethereal oils, numerous volatile and non-volatile organic acids, fats and fatty acids, sterols, numerous hydrocarbons, nicotine and related alkaloids, polyphenols, and pigments. Many of these substances occur in minute amounts only but are essential to the bafflingly complex chemical entity that is tobacco.

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Chapter Ten

GENETICS AND BREEDING OF AROMATIC TOBACCO

Introduction

It may come as a surprise to many persons to learn that *Nicotiana* was first hybridized nearly two hundred years ago by Köhlreuter (1761-1765). He reciprocally crossed *N. rustica* and *N. paniculata* and established, in classical studies, the existence of sex in plants. Subsequently an enormous volume of research has been devoted to problems involving the genetics of species of *Nicotiana*. Much of it has dealt with varieties of cultivated tobacco but relatively little genetic study has been concerned with tobaccos of the aromatic type. Nevertheless, it is obvious that anyone desirous of conducting genetic studies of aromatic tobacco should become conversant, first of all, with the results of genetic investigations of all types of cultivated tobacco and also with those of all other species of *Nicotiana*.

For years, *Nicotiana* has been a favorite subject for study among geneticists. They have selected this genus mainly because (1) tobacco grows well on many kinds of soil, (2) its flowers are large, hence can be manipulated easily in crossing, (3) seeds are produced abundantly, there being 1000 to 3500 in each capsule, and (4) the seeds retain viability for years. As a consequence of its suitability for genetic studies several fundamental researches on *Nicotiana* were made during the later part of the nineteenth century and the early years of the present one. Among them, the studies of Comes (1899), Catalano (1953), and of Howard and Howard (1910) are outstanding. The stimulus for some of the more recent ones was provided by the finding of Mendel's classical report (1865) of a genetic study of peas. The existence of this report long remained unknown because it was published in an obscure journal. Among these recent researches are those of East (1928), and his associates in New England, and of a group at the University of California, including Setchell, Goodspeed, Clausen, Cameron, and others. Goodspeed's monograph (1954) contains a summary of the investigations made at the University of California during a period of more than fifty years, and also of similar or pertinent studies made elsewhere. It deals with the sixty presently recognized species of *Nicotiana.* Geneticists have made many interspecific and intraspecific hybrids. As regards interspecific hybrids, Goodspeed states that *Nicotiana tabacum* has been crossed with each of the following species: *alata, benthamiana, bigelovii, debneyi, exigua, glauca, glutinosa, longiflora, nudicaulis, otophora, palmeri, paniculata, pauciflora, plumbaginifolia, raimondii, rustica, setchellii, solanifolia, suaveolens, sylvestris, tomentosa,* and *tomentosiformis.* The usefulness of interspecific hybridization as presently employed in disease and pest control and of matters pertaining to crosses among varieties of *N. tabacum* will be considered later in this chapter.

Species and chromosomes

To appreciate the limiting factor in interspecific hybridization it is necessary to realize that two species can be successfully crossed only if there occurs a mating of homologous chromosomes. As might be expected, species having chromosomes that are similar and of equal numbers hybridize most readily. But not all species of *Nicotiana* possess such sets of chromosomes. A classification of species of *Nicotiana* by Goodspeed (1954) takes into account the haploid number of chromosomes as one basic factor for the groupings. He divided the genus into three subgenera within each of which the most closely related species are grouped into sections. Following this plan he arranged the species of *Nicotiana* in the manner shown in Table XLVIII.

As shown in the foregoing tabulation 28 of the 56 species of *Nicotiana* have 12 pairs of chromosomes, 11 have 24 pairs, 4 have 16 pairs, 4 have 9 pairs, 2 each have 10, 19, and 20 pairs, and one each has 18, 21, and 22 pairs.* Goodspeed (1954) states that among the Solanaceae, *Nicotiana* is the only genus with many chromosome numbers. As may be noted half of the species are 12-paired haploids, 20 are euploid, i.e., have a chromosome number that is a multiple of the basic number, some being lower, others higher than 12,

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* Five new species and two new subspecies recently have been described from Australia (Burbidge, 1960). Two of these new species have 23 pairs of chromosomes.

TABLE XLVIII. SUBGENERA, SECTIONS, HAPLOID NUMBER OF CHROMOSOMES, AS DETERMINED BY VARIOUS INVESTIGATORS

Subgenus	*Section*	*Species*	*Haploid number chromosomes*	*Authority for counts*
Rustica	*Paniculatae*	*benavidesii*	12	Goodspeed, 1938
"	"	*cordifolia*	12	Goodspeed, 1928
"	"	*glauca*	12	Goodspeed, 1923
"	"	*knightiana*	12	Goodspeed, 1938
"	"	*paniculata*	12	Goodspeed, 1923
"	"	*raimondii*	12	Goodspeed, 1923
"	"	*solanifolia*	12	Clausen, 1928
"	*Thyrsiflorae*	*thyrsiflora*	12	Goodspeed, 1945
"	*Rusticae*	*rustica*	24	East, 1921
Tabacum	*Tomentosae*	*glutinosa*	12	Goodspeed, 1923
"	"	*otophora*	12	Goodspeed, 1945
"	"	*setchellii*	12	Goodspeed, 1941
"	"	*tomentosa*	12	Goodspeed and Clausen, 1927
"	"	*tomentosiformis*	12	Brieger, 1928
"	*Genuinae*	*tabacum*	24	White, 1913
Petunioides	*Undulatae*	*undulata*	12	Clausen, 1932
"	"	*wigandioides*	12	Clausen, 1932
"	"	*arentsii*	24	Goodspeed, 1944
Petunioides	*Trigonophyllae*	*palmeri*	12	Christoff, 1928
"	"	*trigonophylla*	12	Clausen, 1928
"	*Alatae*	*alata*	9	Goodspeed, 1924
"	"	*bonariensis*	9	Clausen, 1932
"	"	*forgetiana*	9	Clausen, 1949
"	"	*langsdorfii*	9	Goodspeed, 1923
"	"	*longiflora*	10	Goodspeed, 1923
"	"	*plumbaginifolia*	10	Christoff, 1928
"	"	*sylvestris*	12	Goodspeed, 1923
"	"	*nesophila*	24	Goodspeed, 1923
"	"	*repanda*	24	Clausen, 1928
"	"	*stocktonii*	24	Clausen, 1932
"	*Noctiflorae*	*acaulis*	12	Goodspeed, 1945
"	"	*noctiflora*	12	Clausen, 1932
"	"	*petunioides*	12	Goodspeed, 1933
"	*Acuminatae*	*acuminata*	12	Goodspeed, 1923
"	"	*attenuata*	12	Clausen, 1928
"	"	*corymbosa*	12	Goodspeed, 1933
"	"	*linearis*	12	Goodspeed, 1945
"	"	*miersii*	12	Goodspeed, 1933
"	"	*pauciflora*	12	Goodspeed, 1923
"	"	*spegazzinii*	12	Goodspeed, 1945
"	*Bigelovianae*	*bigelovii*	24	Goodspeed, 1945
"	"	*clevelandii*	24	Clausen, 1928
Petunioides	*Nudicaulis*	*nudicaulis*	24	Goodspeed, 1923
"	*Suaveolentes*	*exigua*	16	Kostoff, Dogadkin, and Tichououa, 1935
"	"	*maritima*	16	Wheeler, 1935
"	"	*suaveolens*	16	Goodspeed and Clausen, 1927
"	"	*velutina*	16	Wheeler, 1935
"	"	*gossei*	18	Wheeler, 1935
"	"	*benthamiana*	19	Wheeler, 1945
"	"	*excelsior*	19	Wheeler, 1945
"	"	*goodspeedii*	20	Goodspeed, 1934 (from Wheeler)
"	"	*megalosiphon*	20	Goodspeed, 1933 (from Wheeler)
"	"	*occidentalis*	21	Wheeler, 1945
"	"	*rotundifolia*	22	Goodspeed, 1933 (from Wheeler)
"	"	*debneyi*	24	Goodspeed, 1933 (from Wheeler)
"	"	*fragrans*	24	Wheeler, 1945

and 8 are aneuploid, i.e., have a chromosome number that is not a multiple of the basic number. Both euploidy and aneuploidy occur among other families of seed plants, as is well known by geneticists.

There is abundant evidence to show that *N. tabacum* originated as a natural hybrid between *N. sylvestris,* a member of the Alatae section, and some member of the Tomentosae section, each having twelve pairs of chromosomes. Goodspeed found that *N. sylvestris* and *N. otophora* presently have the same natural range of distribution. This fact, therefore, constitutes evidence that *N. sylvestris* and *N. otophora* may have hybridized. Moreover man-made crosses between *N. sylvestris* and *N. otophora* and between *N. sylvestris* and *N. tomentosiformis* yield progeny that looks like *N. tabacum.* Such progeny possess twenty-four pairs of chromosomes, thus showing the *N. tabacum* is an amphiploid. Hybrids of *N. sylvestris* × *N. tomentosa, N. sylvestris* × *N. tomentosiformis* and *N. sylvestris* × *N. setchellii* were found to have 90% good pollen but were completely female sterile. Their embryo sac development failed beyond the two or four celled stage. Some races of these species in recent years have yielded partially fertile amphidiploids.

As all geneticists appreciate, cultivated tobacco is highly polymorphic and extremely plastic, responding well to hybridization among varieties. Within each type of tobacco, i.e., Burley, flue-cured, aromatic, etc., many varieties have been developed by growers and breeders and many more are being developed that are adapted to particular regions or that possess tolerance to various diseases and pests.

How to hybridize tobacco

The operation of hybridizing tobacco is easily performed. After the mother plant has been selected, all young capsules and opened flowers should be removed. The flowers that would open the following day are then opened, either with a forceps or with the fingers, and the anthers are removed. If the anthers have already opened before the flower opens, as sometimes occurs, the entire flower should be removed because it is already self-pollinated. Then a flower having freshly opened anthers on the plant that is to serve as the male parent is selected. The flower is removed and its anthers are brought in contact with the sticky surface of the stigmas of flowers of the mother plant. The pollen will adhere as a whitish deposit. The flower head (inflorescence) should next be dusted with an insecticide, and then covered with a paper bag. The lower end of the bag should be folded or crumpled around the stem and stapled or tied tightly. It may be necessary to place a tag on the pedicel of each flower that has been pollinated and to remove all buds that will open subsequently unless other crosses are to be made later, using the same mother plant.

Seed production

Efforts have been made to stabilize and to maintain pure lines of aromatic types of tobacco in the United States by means of selection. In so doing, each year a field is set aside for the production of these varieties and each year plants are selected and bagged in the following manner. The opened flowers and young seed pods are first removed, insecticide is applied, then the flower head is bagged, and the bag is tied tightly around the stem. Since the tobacco plant is self-pollinated and self-fertile, there is thus afforded no opportunity for crossing. The seed produced by bagged plants become the source for planting for the succeeding year.

Seed for distribution to growers are produced in isolated fields, always using selected bagged plants as sources of seed. But the plants in these seed-fields are not bagged, hence there is always chance of crossing, the pollen being transferred from nearby fields by bees, moths, and hummingbirds. However it has been established that the chances of crossing are not great even though other varieties are planted in proximate fields. Furthermore, growers of aromatic tobacco in the United States never save seed for planting, but depend upon the plant breeder to supply them with seed produced in isolated fields.

By selection and bagging for a series of years, it has been possible to secure a high degree of uniformity within the varieties of aromatic tobaccos being grown. Late-maturing plants have been selected because they are known to be more leafy than early-maturing ones, hence produce the larger yields. Also the population of glandular hairs per leaf is a heritable feature, and this finding has been used as a means of increasing the volume of aroma.

Breeding for tolerance to diseases

In recent years such species as *Nicotiana glutinosa, N. debneyi, N. longiflora,* and *N. plumbaginifolia,* which possess a high degree of resistance or tolerance to one or another disease, have been crossed with varieties of cultivated tobacco to transfer the factors for resistance. Crossing with these species, coupled with selection, has made possible the development of varieties of flue-cured tobacco and Burley tobacco that are highly tolerant to mosaic, black-shank, wildfire, black root rot, and Fusarium yellows.

When breeding for disease resistance involves interspecific hybridization, the progeny may be found to be sterile, or only a few viable seeds may be produced. It has been established in some cases that too slow growth of the pollen tube through the tissues of the stigma and style may be responsible for failure of the ovules to develop and eventually to become viable seed. Sterility of hybrids may also arise from difference between parent species in numbers of chromosomes, making difficult or impossible complementary chromosome pairings. It may be possible to overcome this obstacle (1) by artificial production of polyploids, as can be done by treating the germinating seed with colchicine or (2) by back-crossing with ordinary tobacco as the pollen parent.

Our efforts to breed for disease tolerance have been confined to development of varieties of Samsun, Kavala, and Smyrna with tolerance to black shank. In so doing, flue-cured, black-shank-tolerant varieties were used as the pollen-bearing parents. The progeny was grown in fields infested with the black-shank pathogen. A range of tolerance varying from highly susceptible to highly tolerant was exhibited. Such individual plants as survived the entire season without evidence of black shank and in addition appeared like the original mother plants were appropriately bagged to provide seed for plant-to-row trials in the following year. As a result of selection for a series of years, tolerant varieties that are true to type have been developed (Wolf, 1956).

Apparently efforts in the Near East to control diseases of aromatic tobacco by hybridization are rather limited. Breeding trials are presently being conducted at the Tobacco Institute at Drama, Greece, to develop tolerance to black root rot. This disease causes appreciable losses each year in the Katerini region.

Since powdery mildew is so wide spread in the Near East, Ternovskij (1958) at Krasnodar, U.S.S.R., has concerned himself with the development of resistance to this pathogen. As a result, it has been learned that *N. sylvestris, N. rustica, N. glutinosa*, and *N. sanderae*, when hybridized with *N. tabacum*, yield progeny having a high degree of tolerance. Ternovskij used these wild species, and also a cross between *N. sylvestris* × *N. tomentosiformis* as sources of resistance for hybridization with oriental tobaccos. The powdery mildew resistant varieties that have been secured by him include Dubek 566, Dubek 7, Samsun 47/10, Alma-Ata 315, and Trebizond 161. Psarev and Solov'ev (1958) found that Dubek 7, Dubek 566, and Trebizond 161 are also resistant to mosaic.

Back-crossing

When multiple genes are involved in breeding for tolerance to disease, it is the usual practice to make a series of back-crosses. The need for such a procedure may be brought into question for the following reasons: (1) The progeny of a hybrid in which tolerance depends upon multiple genes will be found to exhibit varying degrees of tolerance, ranging from none at all to very tolerant. (2) Since all of the genes or factors were introduced in making the F_1 hybrid, nothing new can be added by back-crossing. The seed produced by a single F_2 plant or subsequent generations are exceedingly numerous, hence the progeny may be anticipated to contain all possible combinations. (3) By judicious selection among this progeny and selfing, tolerance may be increased as the result of new combinations involving the many genes that together determine the degree of tolerance.

Interspecific hybridization

Interspecific hybridzation, eventually, may not prove to be the best procedure for transmitting tolerance to diseases and pests of cultivated tobacco. It has been amply demonstrated by means of interspecific crosses that varieties which exhibit a high degree of tolerance to one or several diseases can be produced. But there remains the possibility that such tolerant varieties may possess undesirable features contributed by the wild species itself or else arising as a new feature, each parent having contributed a moiety of the factor or the entire factor. This undesirable feature may not be visible but may be appreciated only through the sense of smell, or taste, or of some untoward physiological reaction in the person who uses the tobacco. In fact, this possibility has become a reality in the case of some of the interspecific hybrids. Such results suggest that new varieties arising by interspecific hybridization should be more rigidly screened before being given commerical acceptance. The results also suggest that tobacco breeders would be well advised to search for natural tolerance among varieties of *N. tabacum,* and to enhance such tolerance by selection.

Varietal deterioration

The writer has often encountered the belief that a given variety of tobacco will deteriorate or "run out" if the seed are saved for each succeeding crop and the variety is grown for several years in one locality. There is abundant experimental evidence to show that this belief is *entirely* without foundation. There has been no deterioration among our aromatic varieties during the course of twenty years. Instead each one has been improved gradually. This has been done by selection according to type and by bagging the flower-heads of selected individual plants to be used as sources of seed. When no measures are taken to prevent crossing with plants of neighboring varieties in the seed-field the resultant plants will become a mixture of the different varieties being grown, hence will come to lack uniformity. Such lack of uniformity is usually interpreted as deterioration or "running out."

With the establishment of experiment stations in recent years in Bulgaria, Greece, Yugoslavia, and Turkey concerted efforts have been made in each of these countries to determine which varieties are best suited for different regions and to improve them by selection. In the experimental field, at Cevizli-Maltepe, Turkey, and at Drama, Greece, many different varieties are being grown comparatively. For example, the numerous named varieties, long grown throughout Macedonia, have been grown side by side at Drama. From each kind, individual plants that differ from the others in some feature are selected and bagged. The seed from these selected plants are then used for plant-to-row tests. As a result, a few or as many as a dozen different kinds have been isolated from certain of the *Basma* and *Bachi-Bagli* kinds. In addition, as a result of the comparative trials, a single variety that appeared to be superior in quality to all of the others, has been selected for multiplication. Fields are set aside at the experiment stations to increase seed from this selected kind or kinds. From each such field enough seed are produced to send to growers in different parts of Macedonia. These growers, in turn, save seed. This procedure makes it possible to have 1000 kilograms or more of selected seed for further distribution of the variety throughout the region. To maintain standard varieties this plan must be followed year after year.

Nicotine content

It has long been known that a crop of tobacco grown during a dry season contains a higher percentage of nicotine than does one grown during a season of normal rainfall. Equally well known is the fact that aromatic tobaccos, produced in the Near East where rains are usually scarce throughout the growing season, have a low nicotine content. No doubt scarcity of available nitrogen there accounts in some degree for low content of nicotine, but genetic control remains important. Limited root development in response to close spacing may also be a factor in production of low content of nicotine.

✓By selection, strains can be produced that have less nicotine than is normal or average for the given variety. Anitia and Danau (1958) selected lines among Baneasa, a semioriental variety, and the resultant strains had a nicotine content of 0.27% to 0.38%. Arghyroudis (1958) selected from Greek varieties two strains, T. A. 32 and CC_3, that converted nicotine to nornicotine during sun-curing. When these strains were crossed with certain Turkish varieties it was found that the low nicotine character was controlled by multiple factors. Binopoulos (1958), using T. A. 32, found that moisture favors conversion of nicotine to nornicotine, that nicotine content was increased by dry weather, and that the application of P and K did not modify the nicotine content.

Other genetic characters of aromatic tobacco

Many characteristics of tobacco of unusual occurrence have been shown to be inherited in Mendelian fashion, but there is evidence that some of them are non-Mendelian. Gigantism, which occurs among aromatic tobaccos just as it does among other types, is a Mendelian characteristic. Bolsunov (1951) introduced gigantism into Perustitza and Xanthi by crossing these varieties with a giant plant of another type, and then back-crossing the progeny with the aromatic tobacco parent. But a degree of increase in size over that of the parents seems to be traceable merely to hybrid vigor. For example, at the Alma-Ata To-

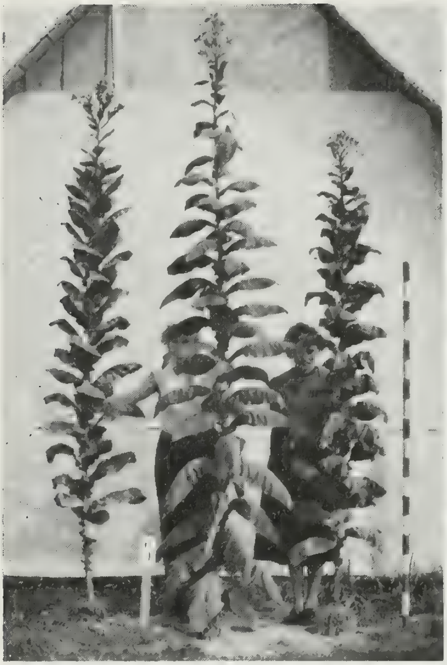

FIG. 96. Gigantism. Plant in middle is parent giant plant. Plant at left is (Giant X Xanthi) X Xanthi. Plant at right is (Giant X Perustitza) X Perustitza. Courtesy I. Bolsunov.

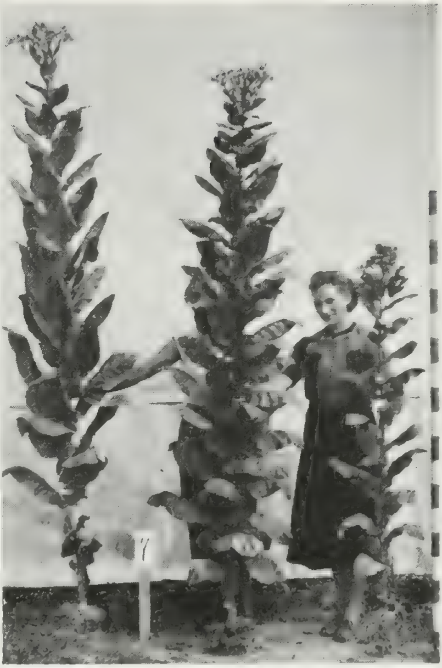

FIG. 97. Gigantism. Plant in middle is parent giant plant. Plant at right is parent Serres-Drama plant. Plant at left is progeny of cross and back-cross of Xanthi. Courtesy of I. Bolsunov.

bacco State Farm in the U.S.S.R., Lukpanov (1958) crossed two strains of Trebizond (Trabzon), namely Trebizond KVX and Trebizond 161, to produce a hybrid that was taller than the parent strains, bore more leaves and larger ones, and had a higher rate of synthesis of dry matter than the parents.

In Rumania, Ioan and Ille (1958) made hybrids of Dragasani × Xanthi Yaka, and Perustitza × Plovdiv 240, and noted that in the F_2, in four-year trials, yield and quality were significantly increased.

In Yugoslavia, Uzunovski (1957) selected from Yaka a strain that gave 52.1% greater yield; its plants were taller and possessed a greater degree of tolerance to powdery mildew, and the cured leaf had a better flavor and a higher phenol coefficient than did the standard Yaka.

In Bulgaria, near Khaskovo, Georgiev (1956) noted a plant that bore sixty-five leaves that was growing among plants that bore twenty-five leaves normally. This many-leafed individual appeared spontaneously.

Structural abnormalities or teratologies, some of them of common occurrence in tobacco, have been, noted by several investigators; but little is known about their inheritance. Ghimpu (1931), in Rumania, noted thirty-two malformations of stems, leaves, and flowers and György (1958), in Hungary, noted twenty-four. In each instance some of them involved aromatic varieties. At the Tobacco Research Institute at Drama, Greece, Dr. Arghyroudis has selected more than a score of abnormalities that he is able to maintain in plant-to-row plantings, showing that they are heritable. These abnormalities include such phenomena as albinism, polyphylly, forked leaf, forked stem tips, gigantism, catacorolla, enation, fasciation, valerian-scented leaf, etc.

An abnormality that is heritable in non-Mendelian fashion was encountered by the writer (Wolf, 1959). It involves albinism in a Kavala variety. The factors governing this defect in the chlorophyll mechanism were found to be transmitted through the egg but not through the pollen.

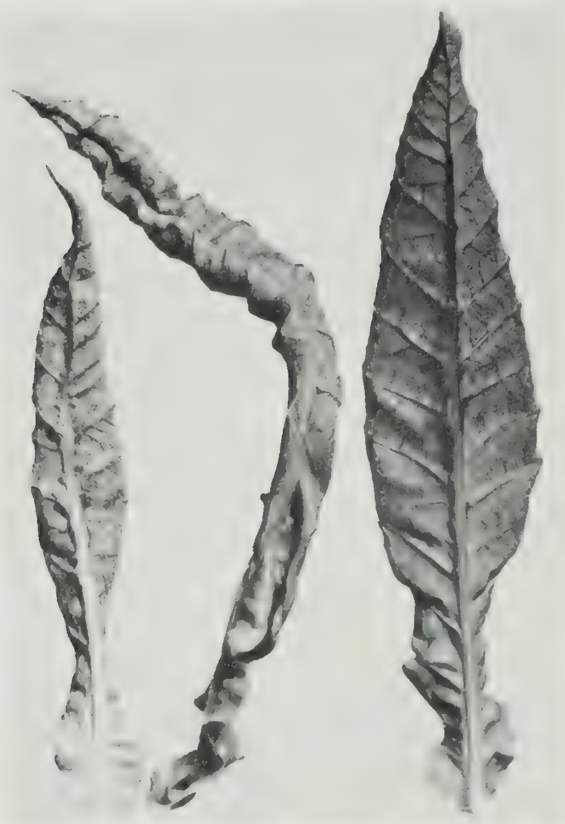

FIG. 98. Leaf abnormality that appeared as a recessive in a cross involving Dixie Bright 102, Kavala, and Guácharo.

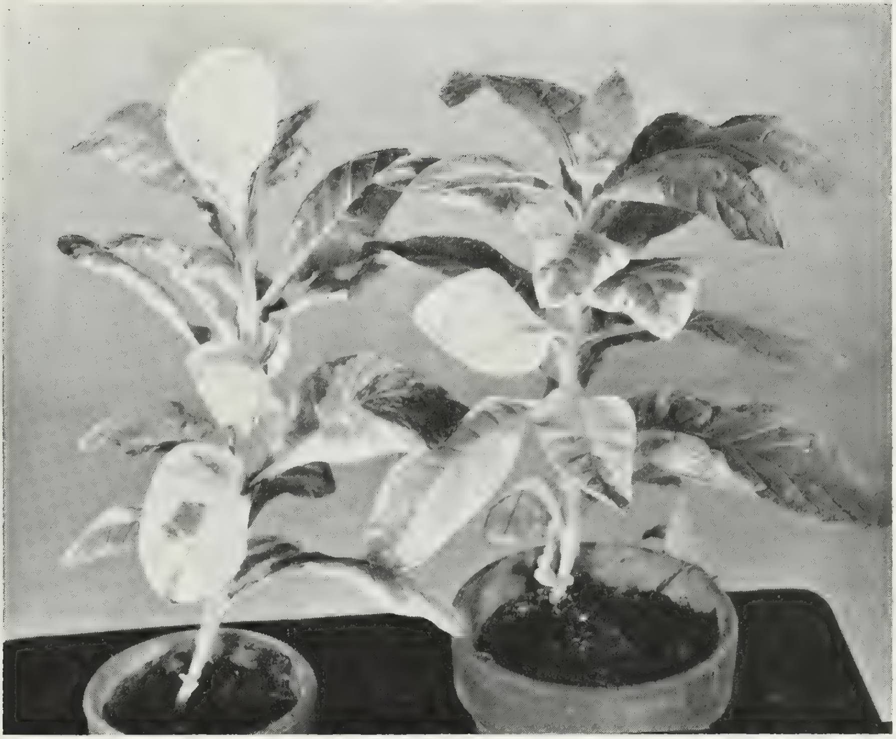

FIG. 99. Albinism in Kavala tobacco. This disorder has been shown to be due to cytoplasmic inheritance.

Pollen from albinistic plants when applied to stigmas of flowers of normally green plants failed to transmit the disorder. Trotter (1939) observed on Ayasolouk plants, in Italy, abnormal leaves that resembled those affected with Kroepoek. Subsequent studies by Wolf (1960) established that this abnormality is inherited as a simple Mendelian recessive.

Summary

Nicotiana tabacum evidently is a natural hybrid between *N. sylvestris* and some member of the Tomentosae section, presumably *N. otophora* or *N. tomentosiformis.* It has twenty-four haploid chromosomes whereas each of its parents has twelve haploid chromosomes. Therefore *N. tabacum* is amphiploid, and because of hybrid origin it is polymorphic. Geneticists have produced many interspecific and intraspecific hybrids in *Nicotiana.*

By means of hybridization and selection aromatic varieties of tobacco have been improved. Improvement is manifest by greater uniformity and increased yield, quality, and tolerance to diseases.

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Chapter Eleven

DISEASES OF AROMATIC TOBACCOS

Introduction

Varieties of aromatic tobacco are subject to the same kinds of diseases as are other types of tobacco. Moreover the economically important diseases of aromatic tobacco in one region are not necessarily identical with those in another. Neither are the diseases that occur in a given region equally destructive year after year. For example, downy mildew or blue mold does not occur in the Near East, in the countries of southern Africa, and in Venezuela. In the southeastern United States, however, it occurs each spring in all seedbeds, unless the seedlings have been protected by application of fungicides. Seedbeds that are not protected may not be seriously affected during a given season but during the succeeding season most of the seedlings may succumb, and even those that survive the attack may be so weakened that they are quite useless for transplanting.

Attention has been directed by several investigators to the occurrence of certain widely prevalent diseases of tobacco in countries of the Near East, but none has been studied intensively. In Turkey, Tomur (1946), by means of graphs, correlated weather factors and damage from diseases in the Black Sea region, Marmara Sea region, Aegean Region, and the regions of eastern Turkey. His observations deal with ordinary mosaic (*adi mozaik*), wildfire (*valişe ateş*) seedling rots (*fide ve kök çürüklükleri*), powdery mildew (*Küleme*), brown leafspot (*yaprak benek hastaliklari*), *Orobanche sp.* (*canavor otu*), and *Cuscuta sp.* (*küsküt*). In a later report (Tomur, 1957), he lists the diseases and pests of tobacco grown in Turkey and provides suggestions for their control.

Information relating to diseases of all types of tobacco and their control may be found in recent books by Hopkins (1956), Wolf (1957), and Lucas (1958). In this chapter brief consideration will be given only to those diseases of major importance to growers of aromatic tobaccos in the several different regions devoted to the production of this crop.

In the southeastern United States, these diseases include mosaic, downy mildew, black shank, and brown leaf spot. In Greece and Turkey they include ordinary mosaic, ring spot, cucumber mosaic, veinbanding, wildfire, damping-off, frenching, black-root rot, black shank, anthracnose, powdery mildew, bassará, dodder, and broomrape; in Venezuela, mosaic, leaf curl, black shank, and ashy mold; in the southern portion of Africa, brown leafspot, frogeye, anthracnose, and mosaic.

Seedbed diseases

Too much emphasis cannot be placed on the employment of sanitary measures in growing healthy seedlings. If vigorously growing, healthy seedlings are available for transplanting at the appropriate season, a uniform stand can be obtained in the field and the quality of leaf from any given priming should be quite uniform.

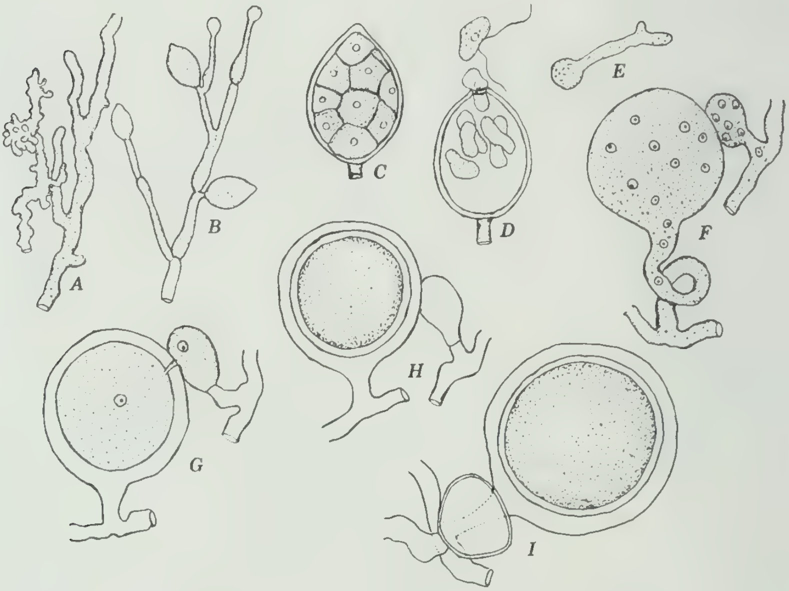

FIG. 100. Structure of Phytophthora: A-mycelium irregular in diameter and nodular; B-sporangiophores that branch below the last formed sporangium; C-sporangium that has become segmented in preparation for discharge of planospores; D-opened sporangium from which the 2-ciliated planospores are escaping; E-after a motile period the planospores come to rest and germinate; F-multinucleate oogonium and antheridium form at the tips of hyphae; G-all nuclei except one in each organ have degenerated and a tube forms for passage of the antheridial nucleus into the oogonium; H-paragynous antheridium; I-androgynous antheridium.

Damping-off—Tobacco seedlings while still in the seedbed are subject to attack by several different species of fungi that cause damping-off, a disease which is characterized by decay of the stem near the soil surface. As a result, the seedlings topple over and die. The causal fungi belong to several genera, including *Pythium, Phytophthora, Fusarium, Rhizoctonia,* and *Sclerotinia.* It should be noted that these same organisms may also attack tobacco at any stage of growth subsequent to transplanting.

If the seedbed soil has been properly disinfested in advance of sowing, if the seedbed is well prepared and provided with a surface layer that contains an abundant supply of organic matter, if the seedbed is well drained, properly watered, and adequately exposed to direct sunlight, damping-off may be entirely prevented. Many growers are convinced that it is advantageous, in order to avoid damping-off, to disinfest their seedbeds year after year. For this purpose methyl bromide is the chemical of first choice, but best results from its use are secured if the soil is treated well in advance of seeding.

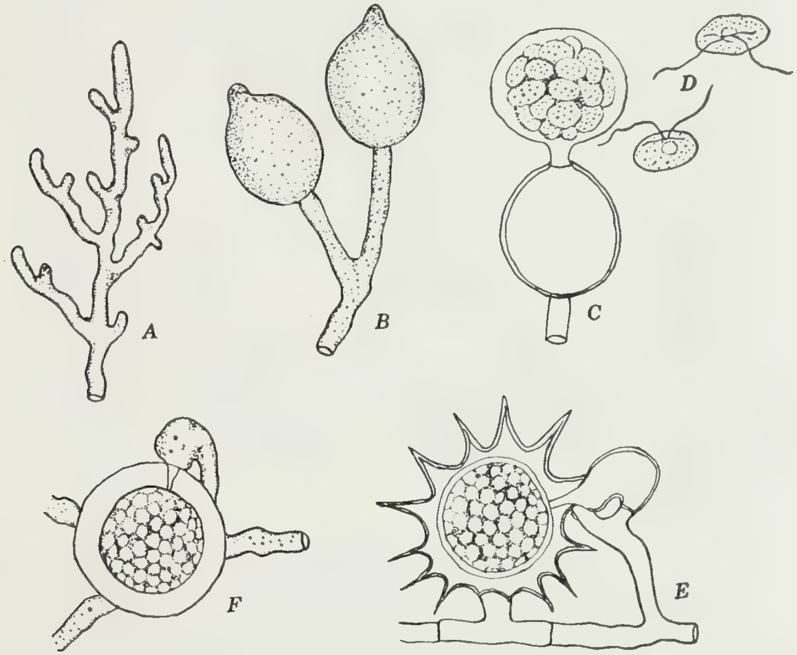

FIG. 101. Structure of Pythium: A-branched hypha; B-pear-shaped sporangia; C-discharge of sporangial content into a vesicle in which planospores are formed; D-antheridium and oogonium of *P. echinulatum* (after Matthews); F-antheridium and oogonium of *P. deBaryanum.*

Downy mildew—Downy mildew, caused by *Peronospora tabacina* Adam, can be very destructive in seedbeds in the United States even if all sanitary measures are carefully observed in the preparation and care of seedbeds.

The causal fungus possesses two kinds of spores or two stages, a hibernating stage by means of which it survives from one season to the next, and a disseminating stage which serves to scatter the organism even for long distances. The spores of the hibernating stage occur in refuse remaining in seedbeds from the previous season. It provides the inoculum for primary infections. The spores of the disseminating stage are air-borne, hence can be introduced from neighboring diseased

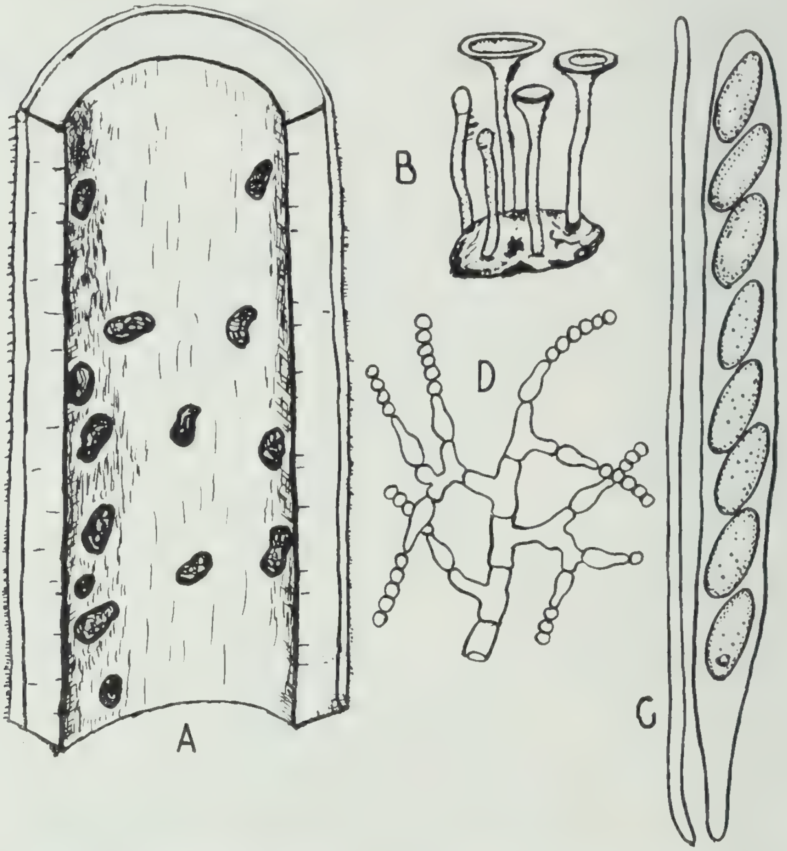

FIG. 102. *Sclerotinia sclerotiorum* (Lib.) De Bary: A-split tobacco stem showing black sclerotia in the pith cavity; B-sclerotium bearing a group of goblet-shaped dics, the discomycetous stage; C-asci containing elliptic ascospores, and paraphysis; D-hypha bearing chains of spherical microspores (spermatia).

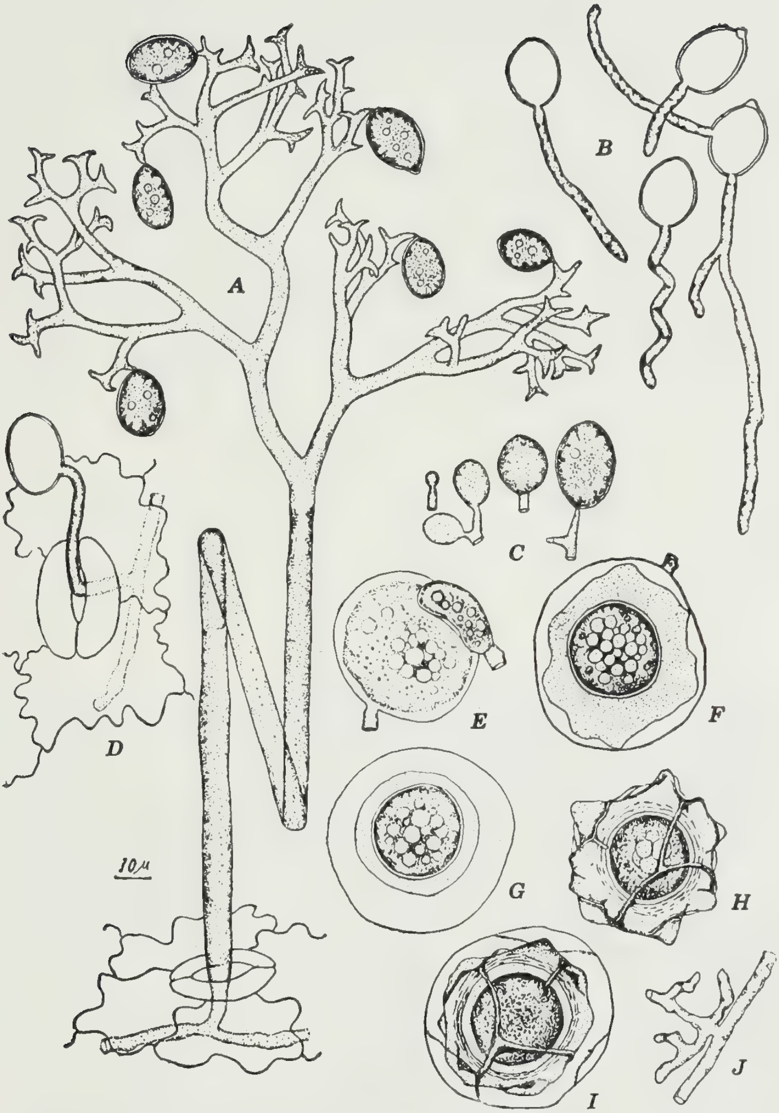

FIG. 103. Structure of *Peronospora tabacina* Adam: A-tree-like sporangiophore with dichotomous apices and a few attached sporangia; B-germination of sporangia in water; C-stages in development of sporangia; D-germ tube from sporangium entering a stoma; E, F, G, H, I, stages in development of oospores as occur within decaying leaf tissues; J-portion of hypha with a branched haustorium.

seedbeds or even from distant ones. Preventive measures are therefore required to protect the seedlings from infection by air-borne spores, or else to ameliorate or to check the ravages after they have become diseased. Each of several fungicides such as Fermate, Dithane Z-78, Parzate Zineb, Zerlate, Parzate, Bizmate, Benzol, or Paradichlorobenzene (PDB) has been proved to be effective. Choice of fungicides is conditioned principally by the cost of materials and amount of labor involved in applying them as sprays, dusts, or gases. The fungicide must be applied in advance of outbreak of downy mildew and the applications must be continued at intervals of three to four days until the seedlings are of suitable size for transplanting, depending upon the frequency of rains. The recent outbreaks of downy mildew in Austria, Germany, and Italy pose a grave threat to the tobaccos of the Near East.

Anthracnose—Anthracnose is among the diseases that occur both on seedlings and on field-grown plants, being especially destructive in seedbeds. It is caused by *Colletotrichum destructivum* O'Gara.

This disease is manifest on seedlings by the presence of numerous

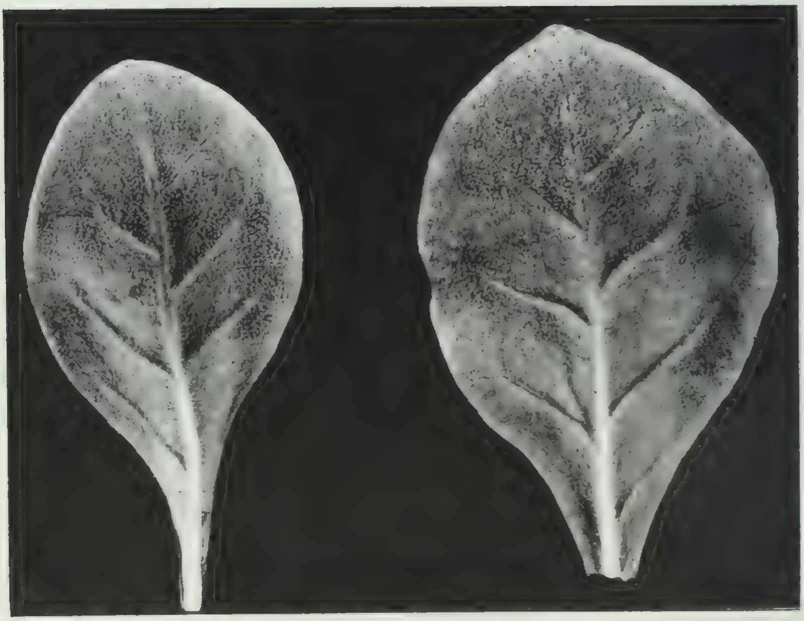

FIG. 104. A pale violet coating of downy mildew as seen in early morning on the leaves of young seedlings. Courtesy E. E. Clayton

circular pale brown to grayish leafspots, and by elongated, sunken lesions on the veins, petioles, and stems. Capsules are also attacked. It is widely prevalent throughout Greece and Turkey on seedlings and on plants in the field.

A body of evidence indicates that the anthracnose pathogen is seed-borne. If seedbeds are systematically treated with any of the fungicides used to control downy mildew, anthracnose is either completely eliminated or is controlled effectively.

Dodders—Throughout the Near East dodders are widely prevalent in seedbeds but rarely occur in the fields. It is presumed that growers discard dodder-parasitized seedlings at the time of transplanting and thus avoid this pest in their fields.

Dodders have the appearance of a mass of densely intertwined yellow strings. But when these stringlike structures are closedly examined they will be found to bear tiny scalelike leaves. Yellow, white, or pink flowers, depending upon the species of dodder, are produced in compact clusters about midsummer. Eventually capsules, bearing seed, are developed. These seed, on germination, give rise to slender vines that wind around the tobacco seedlings. Suckerlike haustoria that penetrate the stems and leaves are formed on the dodder at the points of contact with the seedlings.

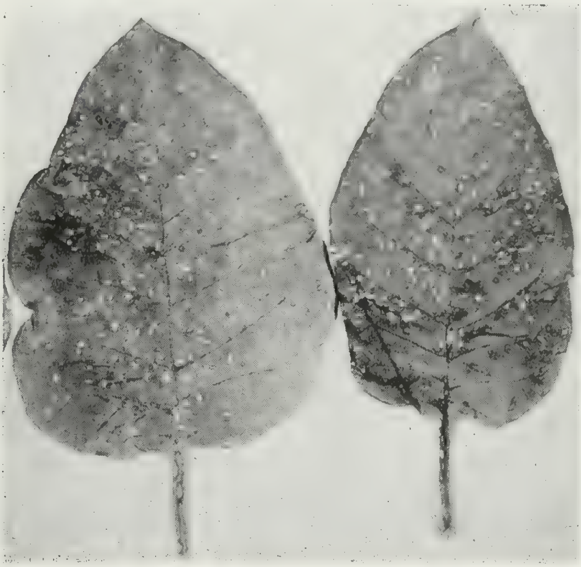

FIG. 105. Anthracnose, *Colletotrichum destructivum* O'Gara, on leaves of Brusa tobacco.

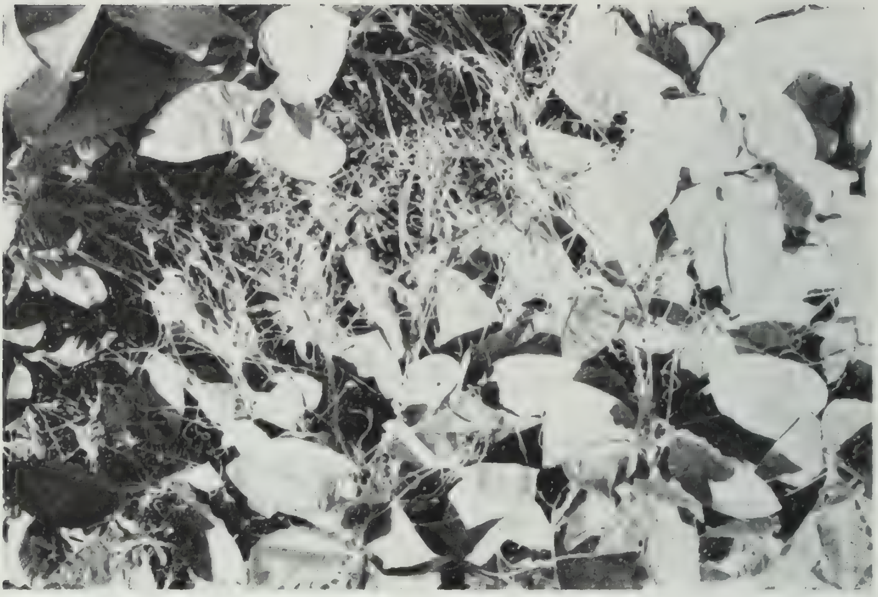

FIG. 106. Dodder, *Cuscuta* sp., on tobacco seedlings growing near Brusa, Turkey.

Several species of dodder, including *Cuscuta epithymum* Murr., *C. monogyna* Vahl., *C. europeae* L., and *C. arvensis* Beyrich are known to parasitize tobacco.

The control of this parasite depends upon its destruction together with its host before the dodder has formed seed. Such destruction becomes especially important when the same sites are employed for seedbeds in successive years. If the dodder is not destroyed before it has produced seed, the site should not be used again for a seedbed until several years have elapsed.

Field diseases

The diseases of the growing crop will be considered under the arbitrary headings root and stem diseases, and leaf diseases.

Root and stem diseases

Nematodes—The root diseases of widest distribution are those caused by nematodes, especially root-knot nematodes (*Meloidogyne spp.*) and meadow nematodes (*Pratylenchus* spp.).

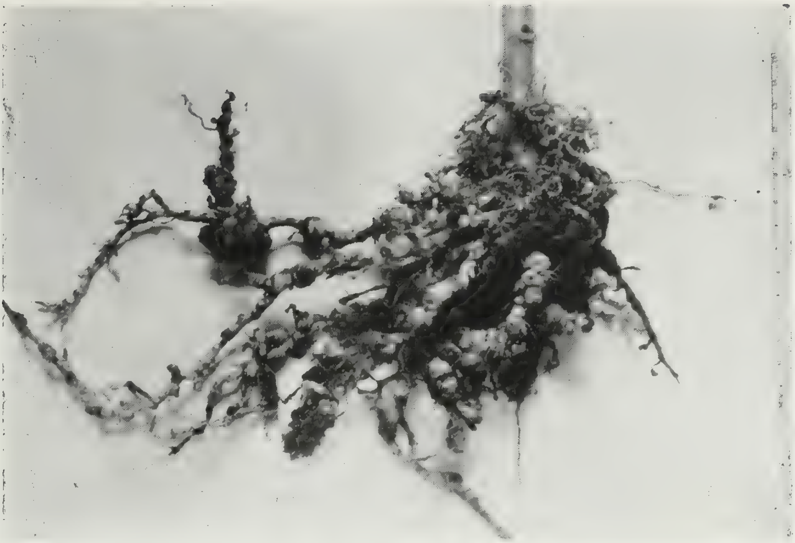

FIG. 107. Roots of tobacco severely affected with root-knot nematodes, *Meliodogyne* spp. Courtesy E. E. Clayton.

Root-knot nematodes bore into the cortex of young roots; in response to their presence knots or galls are formed. If the roots are abundantly infested and rainfall is deficient the growth of root-knot-affected plants may be so retarded that both yield and quality of the crop will be seriously impaired, but more commonly the damage is of minor importance.

Meadow nematodes feed upon the cortical tissues of young roots and in so doing girdle them. The cortical tissues distal to the girdle become moribund and will slough away readily if affected plants are pulled up. As a rule meadow-nematode-infested plants are so severely dwarfed or stunted that the crop is a failure.

In selecting a site for a field in which to grow aromatic tobacco it is essential that nematode-infested soils be avoided. Nematocides applied to infested soils have been found to be effective with other types of tobacco but have not been tested on fields planted to aromatic tobacco. The root-knot nematode population of an infested soil may be greatly reduced if the tobacco roots are plowed up promptly at the end of harvesting. By this means one prevents the production of the late-season broods, and many of the nematodes are killed as a result of desiccation. Both of these groups of nematodes are widespread in tobacco fields in Greece and Turkey.

Black shank—The primary cause of black shank is *Phytophthora parasitica* Dastur var. *nicotianae* (Breda de Haan) Tucker. As the common names indicates, the part of the stem near the ground level is the main point of attack. The roots also become blackened and decayed, and during rainy periods large patches of dead tissues may appear on the leaves. A characteristic feature of this disease is the presence of platelike partitions in the pith, which may be noted only if a diseased stem is split lengthwise. The black-shank pathogen has been found to survive in the soil from year to year. For this reason the prevention of black shank depends upon the avoidance of infested soils as sites for fields. If this is not feasible then use may be made of varieties that have a high degree of tolerance to this disease. Fortunately varieties of aromatic tobacco that possess such tolerance are available. They have been developed as the result of hybridization and selection, tolerance having been derived by use of a black-shank tolerant flue-cured variety as the pollen-producing parent. The progeny was grown in black-shank infested fields, and survivors were selected as seed sources (Wolf, 1956). After about ten years of plant-to-row breeding and selection, highly satisfactory strains of each of the three types Samsun, Izmir, and Kavala have been obtained.

In areas in which black shank is prevalent, the seedbeds should be located on sites free from drainage from infested fields. It has been

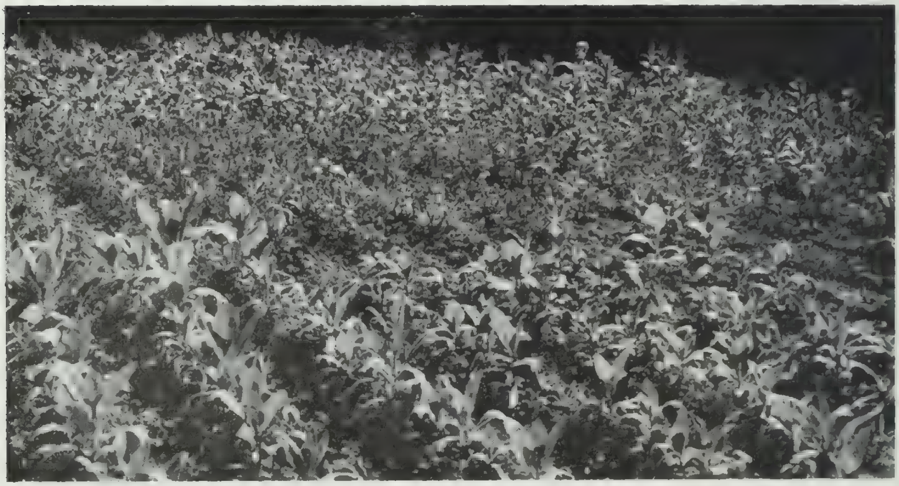

FIG. 108. An area in which aromatic tobacco plants are being killed by the black shank fungus, *Phytophthora parasitica* Dastur var. *nicotianae* (Breda de Haan) Tucker.

firmly established that inoculum may be carried from the seedbed to fields, or from field to field on the shoes of laborers, on the hoofs of domestic animals, or on farm tools and implements.

Black shank was first identified as occurring in Greece in 1930 (Sarrejanni and Stamatinis, 1935). Strangely, it is not seriously destructive there. Even when infested fields in Greece or in Turkey are planted to tobacco year after year, only occasional plants are killed, whereas in the United States nearly all of the plants in extensive areas succumb. In explanation it is suggested that perhaps dry summer weather and high soil temperatures inhibit the spread and development of the black-shank pathogen throughout that region. This suggestion appears to be reasonable because wet soils or soil solutions have been shown to stimulate the pathogen to produce sporangia and motile spores (Wills, 1954).

Ivantcheva-Gabrovska (1958) noted that early-maturing varieties are more susceptible to attack by the black-shank fungus than are late maturing kinds. Such varieties as Banat, Ialomita, Molovata, and Zihna-Kanalion possess a marked degree of tolerance to the black-shank pathogen.

Ashy mold—Ashy mold is so called because the pith in the dead basal stem region of affected plants is destroyed and replaced by dense, ashy-gray wefts of fine threads, the vegetative parts of the causal fungus, *Macrophomina phaseoli* (Maub.) Ashby. The affected woody stem tissues become densely occupied by minute black sclerotia, observable only by use of a microscope. Periods of hot, dry weather appear to predispose tobacco plants to attack. Many other species of crop plants, especially legumes, are suscepts. Partly for this reason, in a rotation system, a crop of legumes should not be grown on a given field during the year preceding the planting of tobacco in that field.

Black-root rot—The fungus that causes black-root rot, *Thielaviopsis basicola* (B. & Br.) Ferraris, is widely dispersed in soils throughout the world. This fungus is of historical interest to plant pathologists because it is the first tobacco pathogen to be controlled by the use of resistant or tolerant varieties.

The most significant facts established from investigations of black-root rot are that it is profoundly influenced by soil temperature and acidity. The fungus is unable to attack tobacco in soils having a pH value of 5.6 or lower, at any normal temperature. The application of lime to soils of tobacco fields is therefore contraindicated. Moreover at soil temperature above 26° C. there is little if any infection, even when the soils are abundantly infested. Black-root-rot resistance presently is being sought in Greece among aromatic tobaccos. Such efforts should be successful in view of the fact that varieties of cigar, Burley, and flue-cured tobacco have been developed that possess a high degree of tolerance to this disease.

In tests of both oriental and non-oriental varieties, conducted during the period 1950 to 1954, Ivantcheva-Gabrovska (1960) noted that all were more or less susceptible to black-root rot but that a moderate degree of tolerance was exhibited by Molovata, Djebel 264, Enidje 7-2, Solunovo seme, Rila 9, Nevrokopska Basma 7, and Ustina.

Leaf diseases

Tobacco mosaic—Ordinary mosaic is among a group of virus diseases known to occur on all types of tobacco everywhere. As the name indicates, it is characterized by a mosaic or mottling of dark green and yellowish-green colors. At times leaves may be variously distorted and the entire plant may be stunted. The extent of injury depends mainly upon the stage of growth at which the plant becomes infected. Yield and quality are materially reduced by mosaic in Maryland, Burley, and flue-cured types, and it may be assumed that aromatic tobacco also is similarly affected; however, no specific data on the effects of mosaic on aromatic tobacco are available.

Mosaic is not a seed-borne disease. The virus may survive the winter in fields in which mosaic was prevalent during the preceding summer. For this reason it is advisable to employ a system of crop rotation. Quite usually the source of inoculum in seedbeds is natural leaf chewing and smoking tobacco or else cigarettes and snuff. The grower is well advised to abstain from the use of tobacco while removing weeds from the seedbed, and while pulling plants and transplanting them. As an added precaution he should thoroughly cleanse his hands by use of tri-sodium phosphate (washing powder) before handling transplants. The grower himself is the primary agent of spread of the inoculum in the field as a result of coming in contact with first diseased and then healthy plants while hoeing, cultivating, topping, suckering, and harvesting.

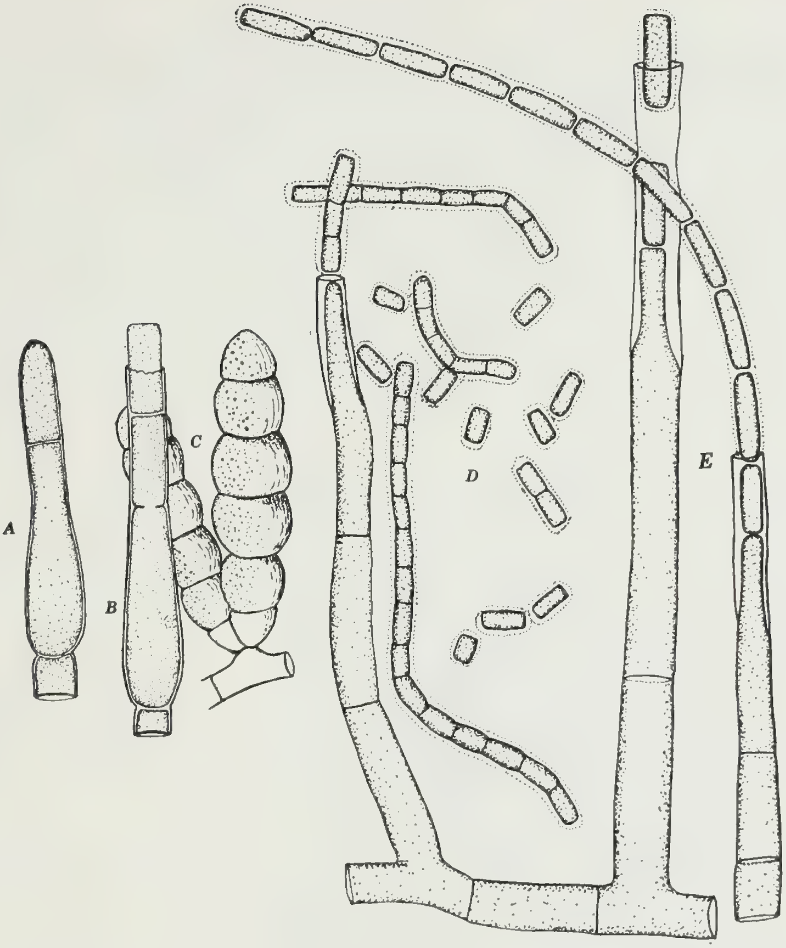

FIG. 109. *Thielaviopsis basicola* (B. and Br.) Ferraris: A-conidiophore with first conidium formed endogenously; B-conidiophore with protruding conidium; C-Chlamydospores; D-mucoid material invests the conidia and holds them in chains; E-conidiophore and chains of conidia.

Certain species of weeds, such as horse nettles and ground cherries, which are related to tobacco, are known to harbor the mosaic virus and therefore should be eliminated from the area immediately surrounding the seedbeds.

Leaves of mosaic-affected aromatic tobacco, during curing, may become spotted, presenting an appearance that is quite like that resulting from accumulation of droplets of moisture when the leaves are being wilted and yellowed. In Turkey and Greece this type of spotting is called *aladja*.

Frenching—Frenching has been of concern to tobacco growers for nearly three hundred years but its cause long remained unknown. It has been recorded as occurring in all tobacco-growing regions, but does not appear to be of major importance in aromatic tobacco culture. The writer observed this disorder in seedbeds and fields in the Near East only in the vicinity of Komotini, Greece. Steinburg, *et al.* (1950) established that frenching is caused from the presence in the soil of certain amino acids, such as isoleucine and hydroxyproline. These acids normally arise as products of bacterial decomposition of proteinaceous materials. He found these acids to be very toxic to tobacco, concentrations of one to five parts per million being sufficient to cause this disorder.

Ringspot—Ringspot on aromatic tobacco is widespread in the United States. However the writer observed this disease in the Near East in a single locality, near Xanthi, Greece. It is a virus disease with a known suscept range that is in excess of 140 species occurring in 40 families of seed plants.

Cucumber mosaic and veinbanding—Both of these virus diseases were noted to be present in Greece and Turkey, but in a few fields only.

Leaf-curl—In the southern part of Africa and in Venezuela leaf-curl or *kroepoek* occurs on aromatic tobacco as well as on other types. This disease is caused by a virus that is transmitted by any one of several species of white flies belonging to the genera *Bemisia, Trialeurodes,* and *Aleurotrachelus.* Manifestly prevention and control of leaf-curl center upon the control of these insects. White flies normally feed upon a wide range of plants, including wild and cultivated species, that occur in the area surrounding the seedbeds and fields. Such chemicals as DDT, ammate, and 2-4 D, applied as sprays to the food plants, have been employed in several regions to destroy the white flies and thus to control satisfactorily this leaf-curl disease of tobacco. The latter chemical should never be applied to tobacco plants.

Wildfire—Wildfire is a bacterial disease of tobacco that has been reported from tobacco-growing regions in nearly all countries of the world. In some areas it appears sporadically, but in others it is destructive year after year.

The causal organism is *Pseudomonas tabaci* (Wolf and Foster) Bergey. This bacterium has been shown to be capable of attacking many species of *Nicotiana* and related species of Solanaceae. Moreover its suscepts include members of about a dozen other families of flowering plants. The ability of the wildfire organism to produce a potent exotoxin is among its unusual characteristics. Woolley, Schaffner, and Braun (1954) isolated and identified this toxin, which they designated tabtoxinine. This exotoxin if sprinkled upon the leaf surface induces destruction of the chlorophyll and death of the tissues.

Investigations have established that this pathogen is seed-borne and

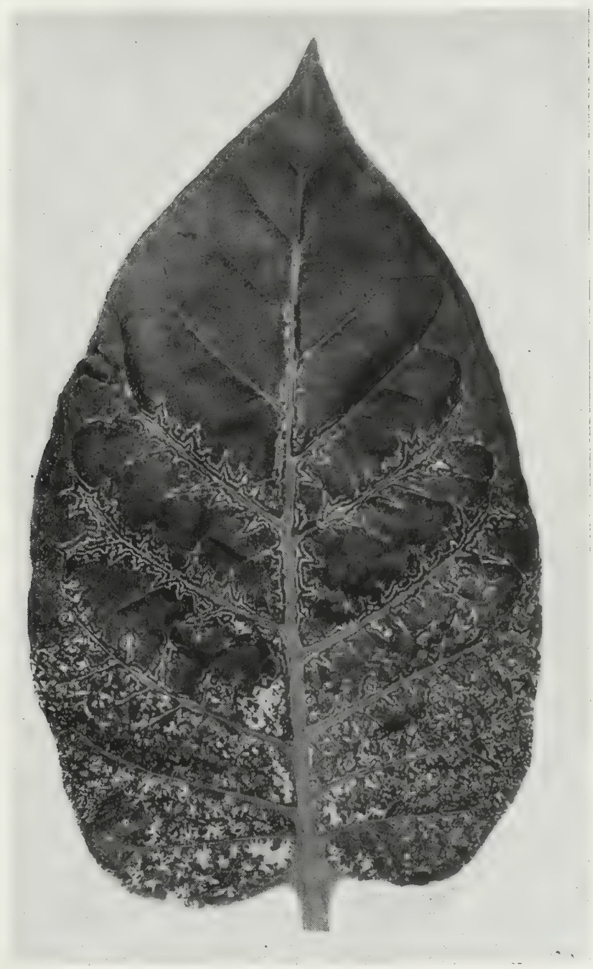

FIG. 110. Systemic streak necrosis in Turkish tobacco. Courtesy A. S. Costa.

soil-borne. These facts provide the basis for employment of seed treatment and crop rotation as means of prevention and control.

Powdery mildew—This disease is widely prevalent in seedbeds and in fields in Turkey and Greece. The primary cause is *Erysiphe cichoracearum* D. C. In Turkey the disease is known as *küf*, or *kuleme*. It may be recognized by the presence of powdery white patches on the leaves and stems, usually appearing first on the lower leaves and spreading upward. The powdery mildew fungus has two stages, a conidial stage which provides for its wide dissemination, and an oospore stage by means of which it hibernates. The oospore stage develops near the close of the growing season. Ducomet (1924) found that this stage is present in the vicinity of Cevizli-Maltepe, Turkey, during August. It causes the leaves to become prematurely yellow. Such leaves are thin, papery, and without commercial value. Plants in low-lying, moist situations where air drainage is inadequate or in seedbeds that are shaded by nearby trees are most severely affected. Hopkins (1956) recorded that powdery mildew attacks both seedlings and field-grown plants and recommends the use of sulphur for its control. He found that the application of sulphur to the soil at time of transplanting, at the rate of forty pounds per acre, markedly checks the development of this disease on the growing crop.

Brown leafspot—To date the aromatic tobacco varieties grown in the southeastern United States have remained remarkably free from

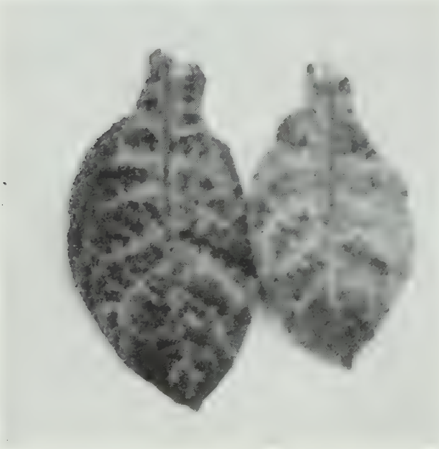

FIG. 111. Powdery mildew, *Erysiphe cichoracearum* DC., on Basma tobacco leaves grown near Xanthi, Greece.

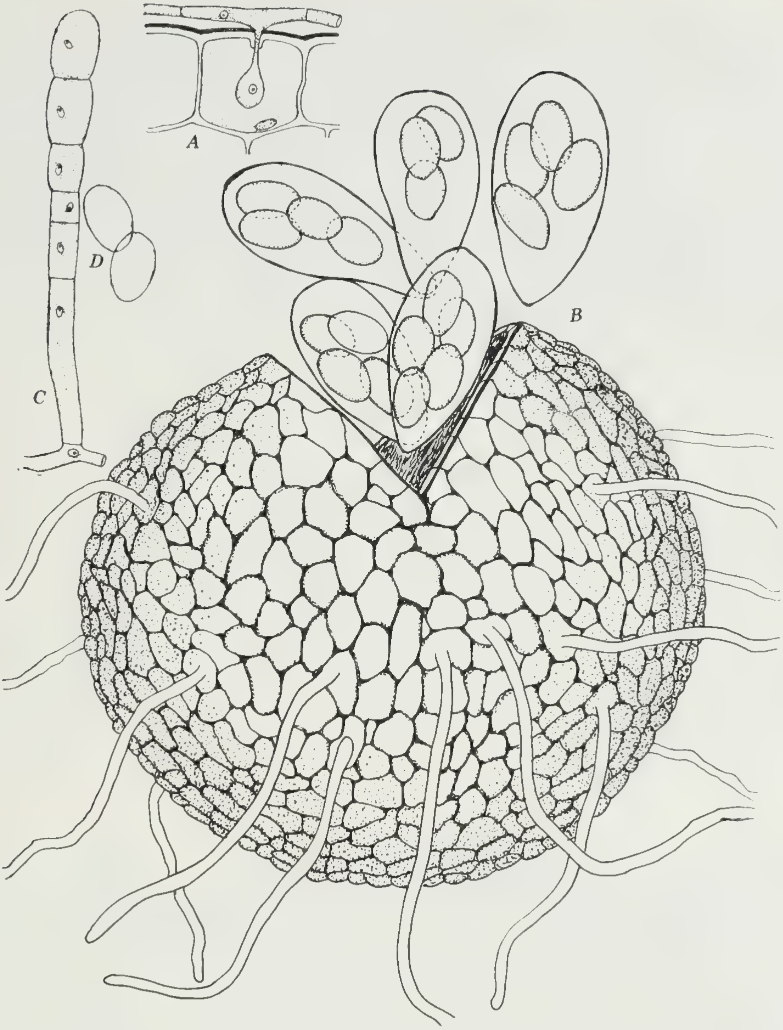

FIG. 112. Structure of powdery mildew: A-superficial hypha with bulbous haustorium within an epidermal cell; B-cleistothecium crushed to permit escape of asci containing ascospores; C-erect conidiophore forming a chain of conidia of the Oidium stage; D-mature free conidia.

leaf diseases except brown leafspot. This disease is caused by *Alternaria longipes* (Ell. and Ev.) Mason. It is characterized by the presence of large, circular, light brown, zonate spots. Lesions appear first on the lower leaves, but if rainy weather prevails other leaves become diseased, extending in some cases to the uppermost ones.

While wet weather, in part, conditions the severity of brown leaf-

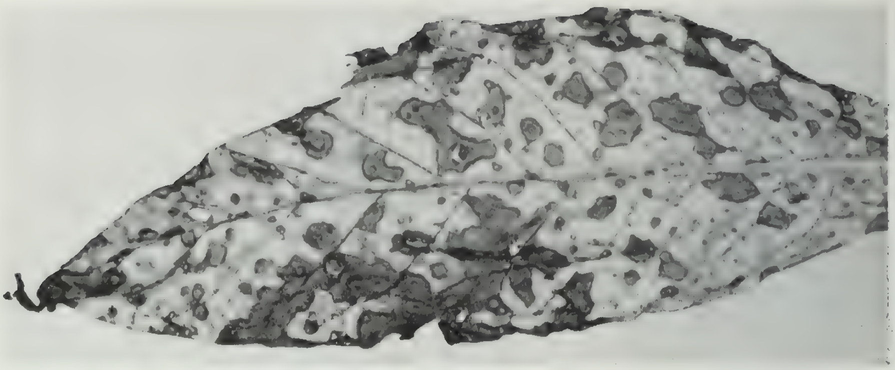

FIG. 113. The brown spot or *Alternaria* spot of tobacco.

spot, its prevalence is determined largely by another factor, the availability of nutrients, especially of potassium. For this reason it is advisable to apply to the soil liberal amounts of potash prior to transplanting.

Frog-eye—This leafspot disease is manifested by the presence of grayish, circular spots with distinct brown borders. Its primary cause is *Cercospora apii* Fr.

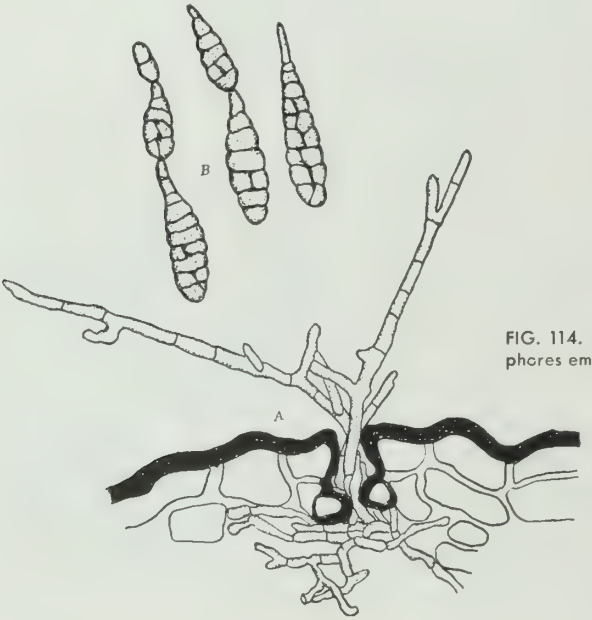

FIG. 114. Structure of *Alternaria:* A-conidiophores emerging from stoma; B-conidia.

Serious outbreaks of frog-eye are usually traceable to the transplanting of infected seedlings. At times only the lowermost leaves of field-grown plants become copiously spotted and the intervening tissues become yellow. However, as the crop matures, if wet weather prevails, the disease may spread to the topmost leaves. Even harvested leaves during the first few days of curing may become abundantly spotted. Because the frog-eye fungus is seed-borne, efforts to control this disease should center on seed disinfection and the application of fungicides to seedlings during their early development in the seedbed.

Broomrape or Orobanche—Various crops are parasitized by flowering plants belonging to the family Orobanchaceae. In Near Eastern countries tobacco is attacked by a member of this family, *Orobanche ramosa* L. This parasite appears as clusters of yellowish plants about six inches tall with scalelike leaves. Upon removing the soil from around the base of these broomrapes it will be found that they are intimately attached to the roots of the tobacco plant. The broomrape is thus nourished at the expense of the tobacco. Flowers and seed are produced about midsummer. The seed may remain dormant until the following season or for several seasons, and will germinate only when in contact with a suitable host species. In Greece a degree of success

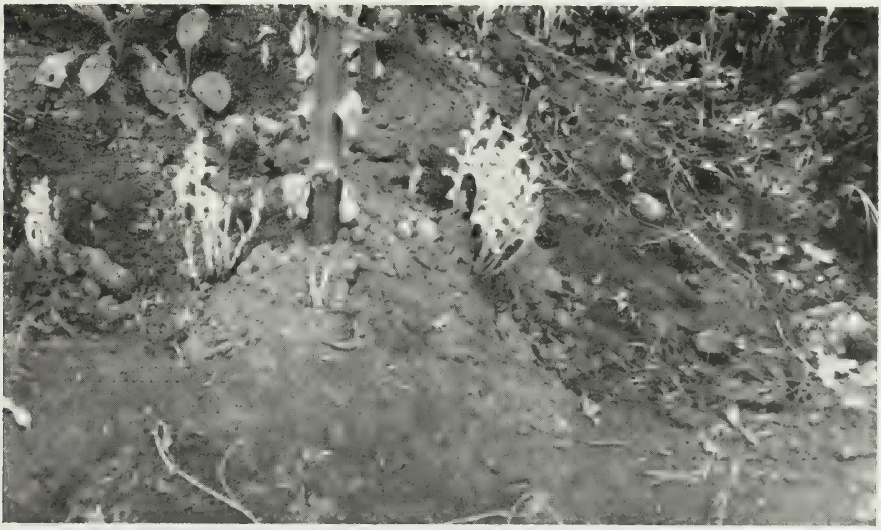

FIG. 115. Broomrape, *Orobanche ramosa* L., on tobacco grown near Salerno, Italy.

in the eradication of broomrape has resulted from planting *Trigonella foenum-graecum* L. (fenugreek) as a trap crop. The timely use of herbicides is indicated to be valuable as eradicants.

Bassará—Bassará is a disease of oriental tobacco of unknown cause that has been reported from several countries of the Near East. At the Second International Scientific Tobacco Congress, held at Brussels, Uzunovski (1958) reported the results of his studies of this disease, conducted at the Tobacco Research Institute, Prilep, Yugoslavia. This disease, although scarcely apparent in the field, manifests itself during curing by the development of irregular, greenish spots that may be very numerous. Abundantly spotted leaves are brittle and chaffy when cured. Uzunovski considered the influence of mineral fertilizers, maturity at harvesting, time of harvesting, date of planting, and effect of topping on incidence of bassará. Apparently wide spacing, late planting, early morning priming, and use of resistant varieties decrease the incidence of this disease. It is the writer's opinion that the accumulation of droplets of water on the leaves during the first days of curing causes bassará.

Summary

Brief consideration is given to the more important diseases of aromatic tobacco. Some of them such as mosaic and damping-off, for example, occur in all regions where this type of tobacco is grown. Certain others, such as downy mildew, occur in the United States and have never been noted in the Near East. Similarly aromatic tobacco in the United States is free of powdery mildew, but this organism attacks this crop in the Near East. To date little has been accomplished to produce aromatic tobacco having tolerance to diseases.

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Chapter Twelve

INSECT PESTS OF AROMATIC TOBACCOS

Introduction

All types of tobacco throughout all regions devoted to the production of this crop are subject to attack by numerous species of insects. Unless the grower recognizes this fact and takes the necessary steps to prevent or control destructive insects he will experience losses. These losses may be very slight at one extreme or else the crop or its products may be completely destroyed. Some species of injurious insects occur abundantly every year, unless controlled, whereas others appear in relatively small numbers and are the cause of appreciable damage only in occasional years.

Cropping and cultural practices are known to constitute important means of modifying the population of destructive insects. Preventive measures directed toward the eradication of their food plants, and the destruction of materials that shelter them during hibernation are also equally important. Very few of the species of insects that feed on tobacco are restricted to tobacco. Measures that encourage an increase in population of predatory insects which prey on species that damage tobacco have been found to be very useful. But these several means of ameliorating losses from insect pests must be supplemented by use of suitable insecticides, applied as dusts, sprays, or fumigants. For species that bite and eat plant tissues, stomach poisons are employed. For species that insert their mouth parts into the tissues and suck out the cell sap, irritant or repellent materials are used. Since certain insecticidal and repellent materials, among them toxaphene and arsenicals, may remain as residues for long periods and thus may occur on the cured leaf, their use on the growing crop is contraindicated regardless of their insecticidal or repellent effectiveness. However, such insecticides may be used safely on seedlings in seedbeds. Certain of the destructive species may attack tobacco at any stage of plant growth, others confine their attacks to plants in the field, whereas others are limited to the cured leaf in storage and to the manufactured products.

Numerous reports are available that were published in the United States by the Federal and State Departments of Agriculture and Experiment Stations ((Howard, 1900, Morgan, 1910, Crumb, 1929, Tenhet and Bare, 1951, Caffrey, 1952). They deal comprehensively with a given tobacco pest or with tobacco-attacking insects collectively. Reports of comparable researches on insect pests of tobacco in Near Eastern countries, however, are much more limited in number and in scope. The following account is a condensation of available reports dealing with tobacco insects.

Key to the most widely-occurring tobacco-attacking insects

It is essential that a tobacco grower should be able to identify at least the most destructive, widely distributed insects that attack his crop. The following key is designed to serve him in this matter. Once he has made the identification he may desire additional information. Such provision is made herein relative to each species, control measures being given special emphasis.

A. Seedbed insects

1. Numerous shot-hole-like perforations of leaves. Look for tiny, black, jumping beetles.
   Tobacco flea beetle
2. Seedlings cut off at soil surface. Also large holes eaten in the leaves or entire top devoured. Look for worms buried near base of attacked seedlings.
   Cutworms
3. Leaves silvery streaked along veins, accompanied by minute dark specks, the very tiny insects themselves.
   Thrips
4. Dense colonies of small, green, soft-bodied insects on the leaves and stems.
   Aphids

B. Insects that damage young transplants

1. Base of stem tunneled out; transplants wilt and die

within a few days after transplanting. Slender, shiny, brown worm present in tunnels of stem.

Wireworms

2. Transplants cut off at soil surface. Dark colored worms occur buried in soil just beneath the surface near cut-off plants.

Cutworms

C. Insects on more mature plants in the field

1. Numerous shot-hole-like perforations resultant from feeding of tiny, black, jumping beetles.

Flea beetles

2. Buds and bud-leaves with large irregular notches or holes. Slender green worms having lengthwise stripes along the sides.

Budworms

3. Large notches and holes in leaf, even veins eaten away. Leaves may be quite completely devoured. Large green worms with horn-like appendage at posterior end.

Hornworms

4 Leaves silvery above, especially along the veins; very tiny, fast-moving, dark specks, the causal insects.

Thrips

5. Dense colonies of green, soft-bodied insects especially on the youngest parts.

Aphids

D. Insects on capsules

Holes bored in capsule and seeds eaten; slender green or brownish worms with lengthwise stripes along the sides.

Budworms

E. Insects of stored tobacco

1. Leaves perforated, holes small; small brown beetles

present. Leaves may be largely consumed, leaving abundance of fecal deposit.
Cigarette beetles

2. Leaves consumed, usually beginning at base and extending toward tip, midrib and veins left quite intact.
Tobacco moths

Flea beetles

Tobacco flea beetles (Epitrix parvula Fabr.), so called because they hop when disturbed, are widely prevalent on tobacco plants beginning with seedlings while in the seedbed and continuing throughout the entire growing season. The punctures or perforations on leaves of seedlings may be so numerous that the seedlings perish while still in the seedbed or soon after being transplanted. The leaves of adult plants may be so riddled as to be quite worthless.

Although flea beetles prefer tobacco plants, they feed voraciously on tomato, eggplant, pepper, ground cherry, jimson weed, and nightshade, all of which species are related to tobacco.

Recommended control measures include early destruction of all tobacco plants after harvest, destruction of trash near seedbeds in which the beetles may hibernate, construction of seedbeds with tightly fitting frames and covers, and frequent application of insecticides such as arsenicals, rotenone ($C_{23}H_{22}O_6$), a ketone extracted from the roots of *Derris elliptica* Benth., DDT($C_{14}H_9C_{15}$), or cryolite (sodium aluminum

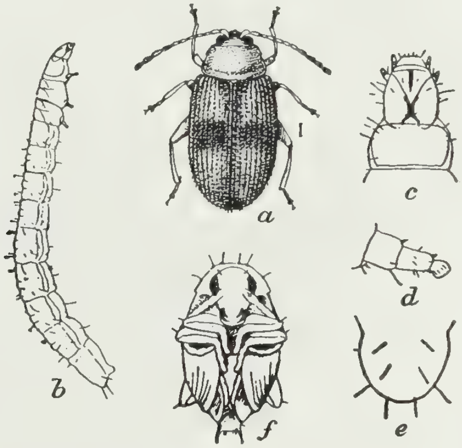

FIG. 116. *Epitrix parvula* Fabr.: *a*-adult flea beetle; *b*-larva; *c*-head of larva; *d*-posterior leg of larva; *e*-anal segment; *f*-pupa. After Chittenden.

fluoride, $AlF_3 \cdot 3NaF$). An application of insecticide made just prior to pulling the seedlings for transplanting is very effective in preventing damage to young transplants.

Cutworms

Cutworms are world-wide in distribution. They include approximately twenty species distributed among several genera, including *Agrotis, Noctura, Prodenia, Feltia, Amathes,* and *Nephelodes.* The adult stages are moths of the family Noctuidae. The larval stages are worms that, when mature, range from one to two inches in length depending upon the species. They also feed upon many kinds of young field and garden plants.

The control of cutworms depends upon the use of poison baits, usually consisting of a mixture of Paris green or other arsenical together with bran and an added attractant such as molasses. The formula for such a bait is: Bran fifty pounds, Paris green two pounds, molasses two quarts. Add water to moisten. Broadcast bait on seedbed or drop some of it beside each newly set transplant.

Thrips

The tobacco thrips (*Frankliniella tabaci* Hinds), called *tütün biti* in Turkey, is a very minute brownish insect that feeds by sucking. In arid regions or during abnormally dry seasons it may be destructive both to seedlings and to plants growing in the field. The insect feeds mostly near the veins causing silvery or whitish streaks to form. Thrip injury in Turkey is called *ak damar* (white vein). Throughout the Near East thrips cause severe damage year after year. It appears to be their most

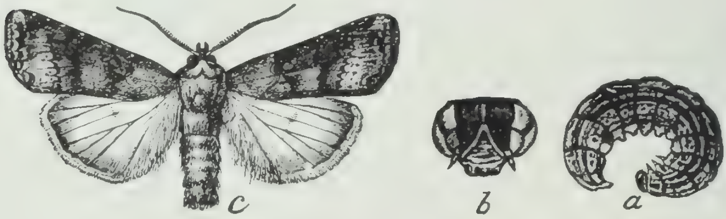

FIG. 117. The greasy cutworm, *Agrotis ypsilon:* a-larva; b-front of larval head; c-adult. After Howard.

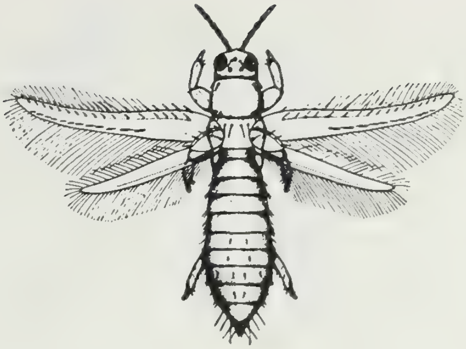

FIG. 118. Tobacco thrips, *Frankliniella tabaci* Hinds.

destructive insect pest and has been extensively investigated by Blunck (1951). Thrips also attack various other species of plants, occurring especially on the lower leaf surface.

Control is very difficult of accomplishment. Rotenone or black nicotine sulphate yields best results. Nicotine sulphate, when diluted by mixing ¾ pound with fifty gallons of water, with three pounds of laundry soap added as a spreader, has given moderate protection. The application of DDT also has given some measure of control.

Wireworms

Insects belonging to four or five genera of click beetles, *Agriotes, Corymbites, Drasterius* and *Melanotus,* of the family Elateridae or snapping beetles, possess a larval stage known as wireworms. These beetles are brown above and are densely coated below with silvery to bronze colored hairs. If placed on their backs they flip the middle of their body against the ground with a snapping sound. As a result they are catapulted into the air and on landing are right side uppermost.

Wireworms also find many kinds of cereals and grasses throughout the world to be suitable food plants. They bore into the stems of newly set tobacco seedlings and tunnel out the pith. The attacked plants wilt and usually succumb. If the stems of affected plants are split open, a brown, hard-shelled wireworm about half an inch long may be found within the tunneled stem.

Satisfactory control of wireworms has been obtained by use of chlordane ($C_{10}H_6Cl_8$), a chlorinated hydrocarbon. This chemical may be diluted in the water applied when setting the plants. In lieu of this, the roots of the plants to be transplated may be immersed momentarily in a solution of related compound called aldrin ($C_{12}H_8Cl_6$).

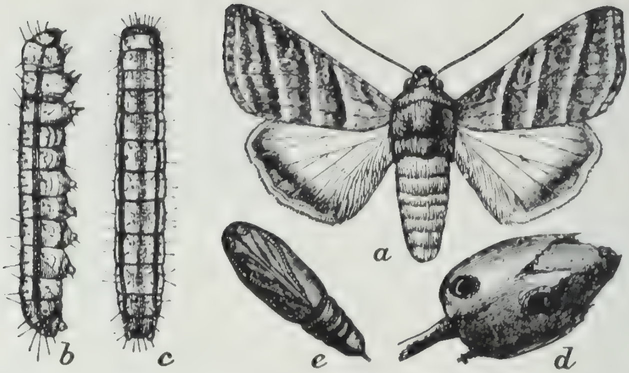

FIG. 119. *Heliothis virescens* Fabr., bud worm: *a*-adult moth; *b*-lateral view of fully grown larva; c-dorsal view of fully grown larva; *d*-capsule bored by larva; e-pupa. After Howard.

Budworms

The budworm (*Heliothis virescens* Fabr.) is green at first with lighter stripes that are lengthwise of the body on each side. Later the worms become brown and when full-grown are about one-half inch long. The adult is a velvety, light green moth, having paler stripes that run obliquely across the wings. Its wing spread is approximately one inch.

As the name indicates, the larvae of this insect attack the bud and young leaves. At first small perforations or notches are formed, but as the leaves expand they become distorted and large areas of tissue are lacking. Larvae also bore through the wall of the capsules or seed-pods and devour the seed.

Effective control follows the use of dust containing TDE, (di *p*-chlorophenyl dichloroethane) ($C_{14}H_9Cl_4$) or endrin (isomer of dieldrin). The growing crop should be inspected frequently, and the first application should be made as soon as the first evidence of infestation is noted. Subsequent dustings must be made whenever they are required to keep the budworm under control.

Hornworms

Two species of hornworms, *Protoparce sexta* Johanssen and *P. quinquemaculata* Haworth attack tobacco in the field throughout the entire season. They are ravenous feeders capable of ruining the leaves and, when abundant, bring about complete defoliation. The worms are large and green with white bars on the sides, and have a slender dark horn at the tail end. They are the larval stage of hawk moths. The pupal stage is brown and bears a curious handle-shaped process that issues from the top of the head. The pupae may be found near the plants buried beneath the surface of the soil.

The moths deposit their eggs singly on the lower leaf surface. The eggs hatch to become young larvae within a week. The larvae become full-grown in about a month, then burrow into the ground and transform to pupae. Usually two or three generations are produced during the season.

Effective control has been accomplished from use of TDE, applied as a dust. TDE is quite like the better-known DDT, differing from DDT in that it contains one less chlorine atom.

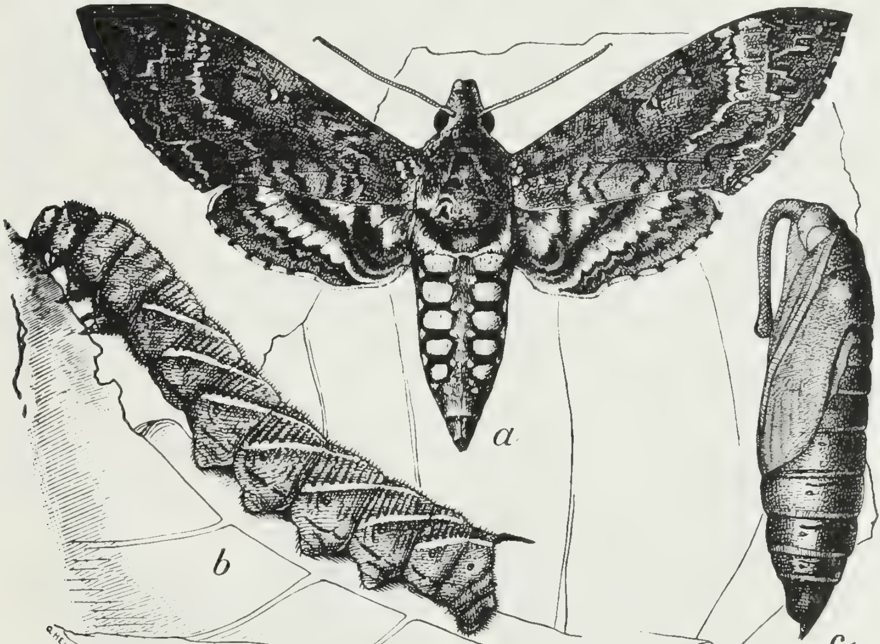

FIG. 120. *Protoparce sexta* Johanssen, horn worm: A-adult moth; B-full-grown larva; C-pupa. After Howard.

Aphids or green plant lice

Aphids, especially *Myzus persicae* Sulzer, are a major pest of tobacco throughout the Near East. These insects suck the juices from buds and young leaves and thus reduce both yield and quality of the crop. They collect in enormous numbers on young parts by virtue of the fact that females bear viviparously many young within a twenty-four-hour period. These insects may become so abundant as to cover completely the buds and leaf surfaces. Dry weather is especially favorable for abundant development of aphids.

Control of aphids is difficult partly because the insecticides must be brought into contact with them. A solution of nicotine sulphate used with soap as a spreader yields quite effective control, especially if applied before the infestation becomes severe. Parathion (diethyl nitrophenyl thiophosphate) has been found to be effective, but this insecticide is very poisonous and great care must be exercised by those who employ it. A related compound malathion is preferred by some because it is less dangerous to handle but is somewhat more expensive.

Storage insects

Unmanufactured tobacco in storage is subject to attack by two very destructive species of insects, cigarette beetles and tobacco moths. Tightly constructed storages, properly screened, are essential to guard against these pests. The temperature of 160° F. maintained during the

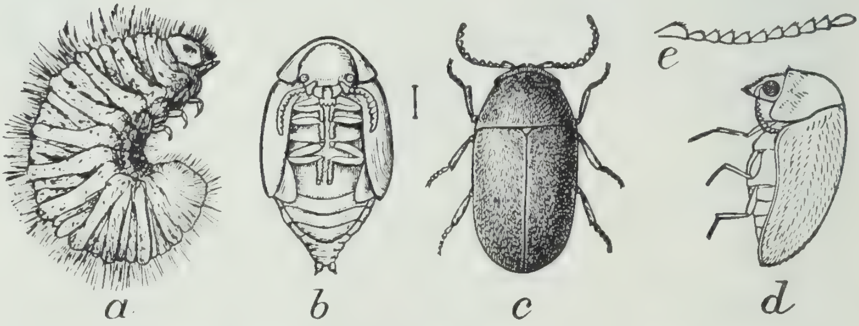

FIG. 121. *Lasioderma serricorne* Fabr., cigarette beetle: *a*-larva; *b*-pupa; *c*-adult moth; *d*-lateral view of adult; *e*-antenna. After Chittenden.

process of redrying at the factories destroys all insect life. But redried leaf is subject to reinfestation after being placed in storage.

Cigarette beetles—The cigarette beetle (*Lasioderma serricorne* Fabr.) has a world-wide distribution and is an exceedingly destructive pest of stored leaf tobacco, cigarettes, and cigars. The damage is produced by its larval stage, leaf of high quality, especially among tobaccos of the aromatic type, being the preferred food. The adult beetles are active throughout the entire year if moderate temperatures prevail. Their flights are limited to nighttime, especially from dusk until about midnight.

Adequate control of the cigarette beetle is very difficult of accomplishment, however, because vapors or aerosols must be used. The reasons are related to failure of the vapors to penetrate the bales or hogsheads, to difficulty of securing a concentration sufficient to be lethal as conditioned by the tightness of the storage and dilution by ambient air, to retention of residues on the treated leaf, and to danger from exposure of the operator to the vapors.

Among the safe and fairly effective aerosols commonly used is pyrethrum, an extractive from several species of Chrysanthemum. Tracy *et al.* (1957) found that vapors from an emulsion of 0.025 mg./liter of DDVP (dimethyl dichlorovinyl phosphate), when employed to give a concentration of 0.7 mg./ft.^{3} of space, kill 96% of the beetles.

Light traps equipped with suction fans aid in reducing the population of beetles within the storages. Hydrocyanic acid (HCN) with ethylene oxide (C_2H_4O) as fumigant, liberated in fumigation chambers that are built to employ a partial vacuum, has been used effectively. But such treatment requires special equipment, proper dosage, proper period of exposure, and skill and safeguards in operating, because hydrocyanic acid is highly poisonous.

Tobacco moth—The tobacco moth (*Ephestia elutella* Hbn.) is becoming increasingly important on aromatic and flue-cured tobaccos, both on the farms and in storages. This insect is gray or grayish-brown, with a wingspread of approximately five-eighths of an inch. The larvae consume the blade tissues, leaving the veins. They usually begin their attack near the leaf base and progress toward the tip. Tobacco of best quality, especially leaf with highest sugar content, is preferred.

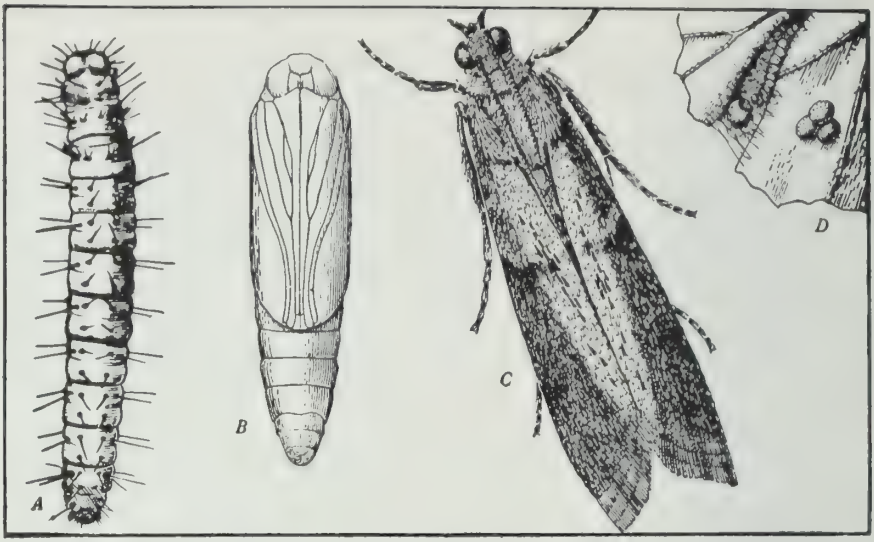

FIG. 122. *Ephestia elutella* Hbn., tobacco moth: A-larva; B-pupa; C-adult moth; D-eggs.

Tobacco trash and scrap left in the grower's packing house or grading room can provide for the survival of the moth from one year to the next. Growers are well advised to destroy all such materials.

Pyrethrum used to fumigate stored leaf for control of this moth has given satisfactory results.

General remarks

Among the various insecticides that have been used to control hornworms, both the tobacco hornworm, *Protoparce sexta,* and the tomato hornworm, *Protoparce quinquemaculata,* none is more satisfactory than TDE. Arsenate of lead and Paris green leave residues of arsenic that are objectionable and may be dangerous when the leaf is smoked. Lindane ($C_6H_6Cl_6$, the gamma isomer of benzene hexachloride) impairs the flavor and aroma of the leaf when burned. Toxaphene persists on the cured leaf, leaving a disagreeable odor.

It is apparent from the foregoing account that the tobacco plant in all stages of development, as well as its products, serves as food for certain species of insects in all tobacco-growing regions. A number of other insects, including suck flies, mole crickets, and grasshoppers may occasion appreciable damage locally, and may be so destructive that insecticides must be used to control them.

TDE may be applied either as a dust or a spray. If used as a dust, ten to twenty-five pounds per acre are needed, depending upon the size of the plants. It is best applied in early morning or late afternoon when winds are absent. If TDE is used as a spray, four pounds of 50% wettable powder, or two quarts of emulsifiable concentrate are diluted in 75 to 100 gallons of water. TDE is effective against not only hornworms but also budworms. Application should be made at a time when these pests are young, while the infestation is slight.

Biological control of hornworms by a bacterial pathogen, *Bacillus thuringiensis* Berliner, has received attention from investigation by Rabb, Steinhaus, and Guthrie (1957), who found it to be quite as effective as TDE. Insect predators, especially wasps of the genus *Polistes,* are known to check hornworm infestations. The most commonly encountered species of *Polistes* are *P. fuscatus* Fabr., *P. annularis* L., *P. exclamans* Vierck, *P. hunteri* Beq., *P. metricus* Say, and *P. rubiginosus* Lepel.

Insecticidal residue on tobacco, as it may be related to the health of smokers, is a subject of increasing interest. For this reason it becomes of utmost importance always to employ insecticides sparingly, at appropriate times only, and in minimal amounts and concentrations. No doubt more emphasis on the control of species of insects that attack tobacco will be placed eventually on region-wide, concerted efforts to eradicate them by timely destruction of their food plants, by use of predators and other biological agents, and by efforts to prevent their reproduction and interfere with their hibernation.

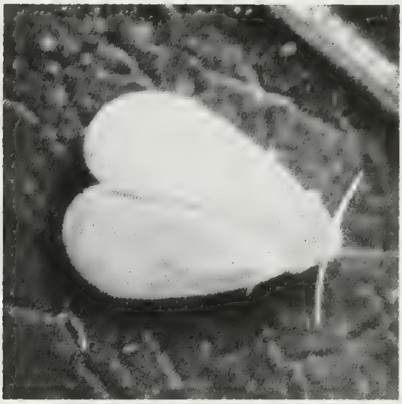

FIG. 123. Adult white fly. Courtesy W. H. Whitcomb.

Summary

The most important insect enemies of aromatic tobacco plants are flea beetles, aphids, thrips, wireworms, budworms, and hornworms; and of stored tobacco, cigarette beetles and tobacco moths. To control them necessitates the use of sanitary measures supplemented by the timely use of appropriate insecticides. The most effective methods of control are outlined herein for each of these pests.

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Chapter Thirteen

ECONOMIC ASPECTS OF AROMATIC TOBACCO PRODUCTION

Introduction

Economic problems involving aromatic tobacco are of concern to growers, workers in storage depots, merchants, manufacturers, and to the governments of all countries in which this crop is grown. These problems involve the wages, working hours, health and social welfare of workers, the administration of credit, taxation, marketing, and exportation, the execution of trade agreements, the regulation of production, international competition for markets, and formation and operation of monopolies, trade organizations and associations, the construction of facilities for storage and shipping of crude tobaccos, and the legislation to provide legal measures for the execution of these matters and operations. All are interrelated and all are of vital importance to the national economy of each aromatic tobacco-producing country. Beltchev (1950) discussed many of these economic problems and their solution as they apply to Bulgaria and it may be assumed that the problems are quite similar in all other Near Eastern countries. These problems are so complex within each aromatic tobacco country and among the various countries concerned that no lasting solutions have been advanced.

The growing and sale of aromatic tobacco, as of any other crop, becomes successful only if it can be done at a reasonable profit. The person who lacks experience with this type of tobacco and who contemplates trying to grow it should be made to realize at the outset that multiple factors are involved in determining whether the production of aromatic tobacco can become a profitable business for him. Among these factors are the cost of labor and materials; the cost of harvesting, storage, and marketing; and an adequate return for his investment in land and equipment. Some of the more important aspects of this complex problem will be given consideration herein.

Small farms and labor

From earliest times in the Near East the acreage available to each grower has been limited and therefore tobacco has been grown on small farms. The amount of labor that the individual grower and his family could provide has governed, primarily, the total acreage that each family unit devotes to this crop. Best practice dictates that the farm must be operated in a way to provide food for the entire family from truck crops, orchard crops, and cereals, and, in addition, to provide feed and forage for the domestic animals. In Rhodesia and Venezuela, however, where large tracts of land can be brought into cultivation, where the supply of native labor is more plentiful, and where, for these reasons, rather large fields of aromatic tobacco, owned by a single individual, are being grown, such is not the case. The Near Eastern farmer can seldom plant to tobacco more than 20% of his entire acreage even though the monetary per-acre returns from tobacco may be several times larger than that from any other crop. He must, therefore, practice what is termed the live-at-home type of farming, and use tobacco as his most important source of cash income.

Actually the fields of tobacco in the Near East, in general, are large, and it is not unusual to find fields of fifty hectares that appear to be a unit. Such fields, however, are constituted of many units, separated from each other by paths, or ditches, and each unit is cultivated by a different grower. Throughout the entire regions the people live together in villages, and their farms occupy the area surrounding these villages.

Market demand is next in importance to the supply of labor in the production of this type of tobacco. Acreage and prices of tobacco throughout the Near East are controlled to a large extent by the governments of the respective countries. In Greece the farmer can plant as large an acreage as he wants to plant, but if there is a surplus the government is not obligated to buy his crop. In Turkey representatives of the government select the areas to be planted, provide seed of the desired variety, inspect the growing crop, and to a degree may supervise the harvesting, curing, and baling. These procedures thus provide for control of quantity and quality and in this way aid in meeting the demands of foreign markets. Less control of production is exercised in Greece; but there, as in Turkey, the governmental agencies do everything possible to promote sales and to keep open the channels of trade in foreign markets. But the desired degree of stability between supply and demand for aromatic tobaccos has never been maintained throughout the Near East, largely because of the disturbed political situations created by the Balkan Wars, World War I, the War of Independence in Turkey, and World War II. Changes in boundaries among the countries have necessitated shifts in population, the refugees being compelled to find new homes and new places of employment. The hardships arising from relocation have been further increased by destruction of factories, processing and storage depots, and other facilities and also of homes, all of which catastrophes are commonly regarded as the natural ravages of war.

Other labor problems

For those who own and operate the factories and magazines for manipulation and storage, a plethora of problems has arisen in connection with the labor market, the extent of organization and unionization of the workers, and the kind of labor laws enacted to improve the health and welfare conditions of workers. Wages have fluctuated continuously. The employer has tried to remedy matters by decreasing costs of manipulation. Also cheaper labor has been substituted for skilled workers by employing increasingly larger numbers of women at lesser cost than the wages paid to men. More and more use is being made of baling in *tongas,* rather than by the classical *basma* and *bachi-bagli* methods, because the making of *tongas* is simpler and less expensive.

The manipulating season does not provide year-long work; hence the employer has encouraged the decentralization of depots for manipulation. By this means the persons who grow and harvest the crop can be recruited as workers for sorting, baling, and fermenting. Additionally, machinery has been installed in factories and storages to reduce hand labor as much as possible. However, decentralization and mechanization, as could be anticipated, have not solved all the problems involving employer and worker. In fact, the execution of these ameliorative measures has created great hardships since many persons had to be transported to new locations, new homes had to be provided, and part of the people were left without employment. In certain Near Eastern countries, since wages paid to women are less than those paid to men, the governments intervened by requiring that at least one-third of those employed in the depots should be men.

Competition in world markets has stimulated the packing of an increasing volume of tobacco in *tonga* bales. The net result has been a decrease in prices paid by cigarette manufacturers for aromatic tobaccos, and also a decrease in total revenue to the processor, to the government, and ultimately to the grower.

One factor of real significance in the cost of manipulation is leaf breakage. Loss from this source can be controlled by careful attention to moisture content of the leaf and relative humidity within the rooms where the tobaccos are being sorted and baled. One might assume that the buyer of tobacco from growers would find it advantageous to purchase dry leaf rather than leaf with natural moisture content. Such is not the case, however, because of potential loss from breakage. Every effort possible must be made to reduce losses from breakage by persuading the grower to exercise great care as to the moisture content while baling the tobacco at the villages and transporting it to market. Similar care must be exercised by the processor during sorting and baling at the depots and also by merchants while the bales are being moved from the storages to the port and are being placed aboard ships.

Obviously, many factors have operated to produce changes in the tobacco industry throughout all countries of the Near East. These changes, in turn, have exerted an influence upon every phase of their national economy. The establishment of processing centers in places most easily accessible to growers has resulted in decreased cost of transportation to market. As an outcome of relocation of such centers roads and rail lines have been constructed to facilitate transportation both to markets and to ports. Also competition among countries for world markets has stimulated the construction and operation of other manufacturing enterprises to produce various kinds of goods and services that are essential to the aromatic tobacco industry itself.

Cost of production

The cost of producing this type of tobacco involves wages, materials, equipment, and a return for use of the land. For several reasons it is difficult to answer satisfactorily the question "How much does it cost to produce an acre of aromatic tobacco?" An experienced grower can produce a crop at less cost than can an inexperienced one. He learns to have a supply of vigorous seedlings at the proper season, to transplant them carefully so that replanting is unnecessary, to prepare the field properly well in advance of transplanting, to avoid or to control pests and diseases, to harvest only those leaves that are mature, to cure them in a way to yield a product having desirable quality, and finally to bale and store the tobacco in a manner to avoid losses from decay and moldiness. To do these things requires, additionally, certain equipment for each operation that must always be available when needed. Mechanization, wherever possible, must be used to reduce costs. Poor judgment, poor management, and inefficient use of labor can be very expensive in the production of aromatic tobaccos.

It should be emphasized that a great deal of hand labor is required to produce aromatic tobacco, more than for the production of any other type. For this reason it became important from the beginning of attempts to grow this crop in the southeastern United States to keep cost accounts. With mechanization and improvements in techniques of handling, especially by planting in furrows, using transplanting machines, and by stringing the leaves on wires in the field, instead of threading the leaves on strings, cost of production has been drastically reduced. As a result the best growers have been able to produce an acre of tobacco yielding 1000 to 1200 pounds, at a labor cost of 648 man hours. Their average cost accounts distribute the per acre expenditures as follows:

* Preparation of seedbeds, seeding, and care of seedbeds	35 hours
Preparation of the field (plowing, harrowing, applying fertilizer)	15 hours
Transplanting in furrows	100 hours
Cultivation of the growing crop	20 hours
Harvesting and stringing leaves on wires	400 hours
Handling (wilting, yellowing, and curing)	30 hours
Bulking preparatory to baling and packing in bales	40 hours
Storing and marketing	8 hours
Total	648 hours

Comparable man-hour requirements for the production of other types of tobacco range from 250 to 450 hours.

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* Data provided by Roy H. Crouse, Tobacco Specialist, North Wilkesboro, North Carolina.

Once the matters of time and labor requirements have been clarified for the person contemplating the growing of this crop, he desires to know what per-acre returns can be expected. The complete answer to this question, like the one involving man hours of labor, can be given only after it has been qualified. One of the factors that must be considered is equipment. In the United States, for example, it has been amply demonstrated that the quality of the cured leaf, hence per pound value, is greatly increased in all cases when growers employ properly constructed curing barns that can be artificially heated when necessary to promote curing by modifying the relative humidity of the air within the curing barn. By use of artificial heat, damage from decay during rainy periods can be completely prevented. Whether sunny weather prevails during curing is of minor concern to the growers having an artificially heated barn, since the tobacco being cured need never be exposed to direct sunshine. In fact, bleaching from exposure to sunshine can be avoided, hence the cured leaves will be uniformly colored.

Per-acre yields

Another factor that must be considered is per-acre yield. The crops produced by some growers have been of such quantity and quality that the gross sales return did not equal the cost of production. On the other hand, yields of 1500 pounds per acre of exceptionally good quality

TABLE XLIX. TOBACCO PRODUCTION IN GREECE IN 1956

Region	Number of villages	Number of growers	Total acreage	Per-acre yield, lbs.	Area per farm, acres	Yield per farm, lbs.
Thrace and Eastern Macedonia	637	74,120	128,211	525	1.72	903
Western Macedonia	620	33,833	73,197	784	1.35	812
Thessalia	128	12,441	16,603	701	1.33	932
Lamia area of central Greece	113	24,015	47,967	510	1.80	918
Epirus	92	4,497	4,433	512	0.98	301
Thivai area	16	931	2,222	578	2.38	1,376
Peloponnesus	63	3,802	13,145	223	2.30	1,103
Aegean Islands	164	8,219	8,329	482	1.10	330
Summary	1,833[1]	161,858[1]	294,107[1]	539[2]	1.62[2]	834[2]

[1] Total. [2] Average.

have been secured, although a yield of 1000 pounds per acre must be considered as very satisfactory. One grower secured a ten-year average yield of 1320 pounds per acre and the eleven-year average yield of another was 1185 pounds per acre. Needless to say each regards the growing of aromatic tobacco as yielding a satisfactory financial reward.

In other parts of the world per-acre yields are equally variable from region to region and from year to year. However, the yields throughout the Near East are less because rainfall during the growing season is not so abundant. In Bulgaria, 600 to 800 pounds per acre represents the range. A yield of 600 pounds per acre in the Union of South Africa and in the Federation of Rhodesia and Nyasaland is regarded as good. In the Izmir region of Turkey the yields are usually less than 600 pounds per acre and seldom more than 650 pounds per acre. In Greece the yield ranges from about 500 to 700 pounds per acre. In the agricultural magazine *Geoponika* for May 1957, there is a report dealing with the production by regions in Greece. The areas of fields are given as stremmata, each stremma being 1000 square meters (approximately ¼ acre), and the yields are given as okas, each oka being 2¾ pounds. These data, when converted to acres and pounds, are summarized in Table XLIX.

Two features are outstanding in the data portrayed in Table XLIX.

TABLE L. ECONOMICS OF PRODUCTION AND EXPORT OF GREEK TOBACCOS FOR THE PAST 15 YEARS

Year	*Cultivated area, hectares*	*Production, metric tons*	*Exports, metric tons*	*Export price per kilo, dollars*
1946	68,600	28,100	12,989	2.28
1947	78,500	47,100	17,835	2.17
1948	72,700	36,600	18,394	1.98
1949	81,200	53,000	28,394	1.59
1950	103,500	58,000	26,369	1.44
1951	93,300	62,500	31,041	1.24
1952	76,500	39,500	43,364	1.25
1953	88,000	61,000	48,924	1.08
1954	106,200	67,400	52,700	1.18
1955	128,400	101,000	55,010	1.40
1956	117,600	82,200	50,010	1.34
1957	122,000	109,800	67,560	1.35
1958	112,500	84,300	61,910	1.36
1959	102,200	78,800	55,990	1.24
1960	94,700	64,000	—	1.49
Av.	96,393	64,886	40,747	

First of all the farms are small, the average tobacco acreage being 1.62 acres per farm, and second the average total production by each farmer is 860 pounds. In the Macedonian region of Greece the average annual crop of nearly 10,000 growers totals approximately 750 pounds per grower.

A better appreciation of the status of the tobacco industry in Greece can be gained from a review of production and exports extending over a period of years. Such data for the last 15 years are assembled in Table L.

It is seen that the total area devoted to growing of tobacco in Greece varies from year to year, due in part, perhaps, to market demand. In addition acre yields vary greatly due to seasonal differences in rainfall. Another very important factor that limits the acreage devoted to this crop is the labor cost required to produce tobacco as compared with that required for other kinds of crops. For example, it is about 12 times as expensive to grow an acre of tobacco, in Greece, as to grow an acre of wheat.

Cost of equipment and materials

Proper equipment for the production of aromatic tobacco in the southeastern United States consists mainly of the curing barn and a furnace having a forced-air circulator. These two items may be regarded as permanent or durable equipment and their cost may be distributed and amortized over a period of years. The following table, LI, contains all of the items needed and their approximate cost.

TABLE LI. ITEMS REQUIRED AND COST

Items	*Capacity*	
	3 to 4 acres	*1 to 1.5 acres*
Curing barn and wilting shed	$ 500.00	$250.00
Forced-air furnace	460.00	270.00
Wires (2000 per acre) (Cost of cutting and bending reduced if done by grower)	195.00	65.00
Sticks (8′ x ¾″ x 1 ½″) 200 per acre	90.00	30.00
Press and priming racks	10.00	10.00
Fumigator and plastic covers	13.00	13.00
Cover for seedbeds	70.00	30.00
total	$1,338.00	$668.00

If the grower is able to mill his own lumber and build his barn with his own hands, the cost of construction can be drastically reduced. Quite satisfactory barns have been constructed at less cost by use of tar paper.

In addition to the items listed a per-acre outlay must be available to purchase the following materials:

Fertilizer, 600 lbs 4-9-3 for 300 square yards of seedbed	$ 13.00
Fumigant, methyl bromide	17.55
Fungicide (Ferbam, 15%)	2.75
Fertilizer, per acre; 500 lbs. 3-9-9,	12.50
plus 100 lbs. potassium sulphate	3.00
plus 200 lbs. superphosphate	2.00
Twine for baling, 1½ lbs. polished cotton twine	1.50
Insecticides, for control of flea beetles, hornworms, and budworms	6.00
Fuel for curing	40.00
Electricity	5.00
Seed for cover crop	3.00
Total	$106.80

Per-acre monetary returns

To determine whether the production of aromatic tobacco will yield a profitable return requires that account be taken of the following matters.

1. Cost per acre in man hours and machine hours.
2. Cost of equipment and materials.
3. Cost of fertilizer.
4. Rental of the land or an equivalent value.
5. Yield per acre.
6. Selling price per pound.
7. Degree of mechanization of all operations.
8. "Know how" of the grower, a very important item.

Unfortunately, few cost accounts are available that cover every phrase of production, harvesting, curing, baling and storage. Van Wyk (1932) stated that aromatic tobacco crops in Cape Province, South

Africa, had been grown at a profit of 46 pounds sterling per morgen (approximately 2.1 acres). Crawford (1957) assembled a body of pertinent data from crops grown in 1958 on 136 farms in South Carolina. These records show an average per acre production of 677.5 pounds, with an average cost outlay of $172.72 and a gross return of $436.01. During the same year, the gross per acre returns by four of the best growers in North Carolina were $1,553.00, $1,461.00, $1,816.00, and $1,142.00, respectively.

The cost of aromatic tobacco production in areas where curing barns and accessory equipment are essential may appear to be prohibitive, especially when it is realized that only a meager outlay for materials is required in the Near East. There the strings of tobacco are fastened to sticks or reeds and are exposed to cure in the sunshine on

TABLE LII. EXPORTATION OF GREEK TOBACCOS DURING 1958 AND 1959*

Importing countries	*Amount (metric tons)*		*Total value, dollars*		*Price, dollars per kilogram*[1]	
	1958	*1959*	*1958*	*1959*	*1958*	*1959*
U.S.A.	13,936.6	6,464.2	23,542,252	10,792,054	1.69	1.66
West Germany	19,708.7	6,381.8	25,387,680	7,433,706	1.29	1.16
East Germany	576.8	416.5	1,037,457	802,290	1.80	1.93
U.S.S.R.	5,053.0	2,614.8	6,195,110	2,688,596	1.23	1.03
Austria	2,349.7	1,156.2	2,135,704	595,228	0.91	0.51
Czechoslovakia	1,292.5	441.6	2,261,184	736,210	1.75	1.67
France	4,728.2	3,151.6	5,138,745	2,902,014	1.09	0.92
Italy	3,487.7	3,601.6	5,923,833	3,746,117	1.70	1.04
Poland	1,039.4	309.4	1,522,842	612,294	1.47	1.98
Hungary	670.6	456.1	909,613	558,399	1.36	1.18
Sweden	286.4	536.9	405,386	785,314	1.42	1.47
Norway	229.9	22.4	289,435	24,904	1.26	1.11
Finland	1,126.5	1,251.0	1,307,467	1,503,267	1.16	1.20
Switzerland	1,296.4	513.8	2,281,080	833,966	1.76	1.62
Belgium	1,976.5	1,139.1	1,387,577	666,060	0.70	0.58
Holland	594.8	315.4	484,703	211,499	0.81	0.67
Great Britain	11.9	56.4	21,677	61,718	1.81	1.09
Portugal	757.0	833.1	362,794	372,581	0.48	0.45
Egypt	1,473.9	37.8	175,013	40,379	1.31	1.07
Tunisia	205.7	245.9	1,930,808	130,681	0.85	0.53
Israel	340.2	277.0	336,953	240,377	0.99	0.87
Uruguay	7.2	44.8	10,784	95,149	1.49	2.12
Cyprus	143.9	109.2	187,798	147,154	1.31	1.35
Australia	8.2	34.0	18,038	71,430	2.20	2.10
Kuwait	17.6	67.4	7,395	30,276	0.42	0.45
Others	587.8	160.3	896,534	99,098	—	—
total	61,907.1	30,638.3	84,157,862	36,180,761	—	—

[1] One Kilogram equals 2.2 pounds.

* Data taken from *Tobacco*, Jan. 29, 1960, do not include those for November and December, 1959.

trellises or on movable racks or frames. Protection from damage by dews or an occasional shower is afforded by the eaves of the house or by a canvas or metal sheet.

Prices of aromatic tobacco

As expected, the prices received by aromatic tobacco growers for their product vary from year to year and from country to country. Similarly the cost of this type of tobacco to the cigarette manufacturer varies from year to year in every country. Many interdependent factors are involved in determining these prices and they need not be discussed herein. It is apparent, however, that they are related to the purchasing power of the standard of value in each different country. An appreciation of the fact that these differences exist and of the magnitude of the range in prices is portrayed by data in Table LII that deal with the sales of tobacco exported from Greece during the years 1958 and 1959.

It is seen that there are wide differences among importing countries in purchase prices of Greek tobacco. No doubt variety and grade of tobacco account in some degree for these differences. Were data available from neighboring countries that export tobacco, they would reflect price differences of similiar magnitude.

The outlook

The production of aromatic tobaccos has increased approximately 30% during the past ten years, but the rate of increase has not kept pace with the consumption of cigarettes or with the increase in the world's population. The countries of the Near East have contributed almost entirely to this expansion which now has reached a total annual production of slightly in excess of one billion pounds. The region will continue, throughout the foreseeable future, to be the center of the aromatic tobacco industry mainly because of edaphic and climatic factors. These factors, especially the dry, hot summers, are widely favorable for the slow growth of the plants, for the abundant secretion of resinous waxy products that are so essential to quantity and quality of aroma, for proper air-curing of the harvested leaf, and for its storage and fermentation. In addition, there is available sufficient labor since over 70% of the people in Greece and Turkey live on the land. No doubt other Near Eastern countries have approximately the same proportional, potential supply of farm labor.

Consideration should also be given to the fact that, on the basis of suitable soils and climate, large areas in Africa, South America, and North America could be devoted to the cultivation of aromatic tobacco. To be sure, the product would not have the identical physical and chemical properties of that grown in the Near East. But as the result of researches it has been found that wherever suitable soils occur and favorable climatic conditions prevail aromatic tobaccos can be grown. Dry weather need not prevail during harvest provided the grower has heated, ventilated curing barns. If maximum temperatures within such barns at no time are permitted to exceed approximately 105°F. there will be no appreciable volatilization of aromatic constituents during curing. Moreover it has been found that suitable varieties can be developed for cultivation in these different countries.

It must not be overlooked that cost of production of aromatic tobacco can be decreased by modification of practices in planting, harvesting, and curing. Machines have been built that are designed to plant two pairs of rows at a time, the members of each pair being 10 inches apart, with an interval of 30 inches between the paired rows. These machines have adjustments that make it possible also to harvest 4 rows at a time. The leaves, immediately after being primed, are placed on wires. Seven persons are needed to operate such a machine, making it possible to prime, once a week, approximately fifteen acres of tobacco.

Temperature and humidity within the curing barn not only can be controlled, but is being controlled automatically. By this means the leaves may be cured with a minimum amount of labor, since it is not necessary to move the tobacco, once it has been hung in the barn, during the curing process.

Governments generally are becoming more and more concerned with problems related to the economic status and well-being of farmers. Two distinct agricultural polices have come into existence, one of which deals with large scale, highly mechanized farms devoted to a single crop or to a few crops, and the other to small, highly intensified and diversified farms. Whether both types of farming can continue to exist side by side in the economy of any country is problematic. Because quality in aromatic tobacco requires a large measure of hand labor and careful attention to details it seems likely that the cultivation of this crop will remain a family undertaking. Its cultivation can be made profitable on small tracts if diversified farming is practiced so as to include the production of field, orchard, and garden crops, also livestock and poultry. With this type of farming, aromatic tobacco could remain an important, profitable, cash crop. However, more and more mechanization in agriculture is inevitable. As a consequence it is being found profitable to grow this crop in large fields.

As is well appreciated, cost of production of tobacco, wages paid for labor, and living standards are not fixed or unchangeable in any region. At present aromatic tobaccos are being grown at less cost in the Near East than in other countries. But economic production and marketing are subject to continuous change and may become seriously disrupted at any time by catastrophic events such as are the aftermath of war. It seems very probable that mechanization of planting, harvesting, and manipulation of aromatic tobacco can be increased to the extent of profoundly modifying the present economic situation. But mechanization will not dignify the word *work,* which in recent years has become more and more opprobrious. The marvels of a short work week, of paid vacations, of early retirement, of numerous fringe benefits, and of the pleasures to be enjoyed by those freed from work have been widely emphasized and publicized as essential to paradise on earth. To toil even with the hands, as must be done to produce aromatic tobacco, must again become a dignified and honorable way of occupying one's time and of earning a living.

Furthermore if and when it ever becomes necessary to increase production on the same acreage presently planted to tobacco in the regions now devoted to the cultivation of aromatic tobacco, it can be done. This can be accomplished with the aid of three procedures: (1) the use of commercial fertilizers, (2) the use of irrigation, and (3) more adequate control of pests and diseases. Agronomic researches in the Near East have already shown that aromatic tobacco responds favorably to the application of mineral fertilizers. Engineering researches have shown that by construction of dams on the streams and the building of ponds and reservoirs, water for purposes of irrigation could be made widely available. The judicious use of irrigation would increase yields, and this could be done without impairment of quality.

Chemical researches have resulted in making available fungicides and pesticides that are effective against the most destructive diseases and insects. Appreciable losses from these causes can be eliminated. There is every reason therefore to feel that the future of the aromatic tobacco industry can be kept secure throughout the world wherever and whenever its problems are handled adequately and intelligently.

Summary

Consideration is given to certain economic factors involved in the growing and handling of aromatic tobaccos. Those factors include availability of labor and its cost, expenditures for equipment and materials, potential market demand for the product, and improvements in technology within the industry.

Costs for labor and equipment are increasing everywhere. With the continuing increase in demand for blended cigarettes containing aromatic tobaccos, there will be an increasing market demand for this type of tobacco. It now seems well established that the growing of aromatic tobacco can be made a successful business undertaking when judicious use is made of cultural and handling practices.

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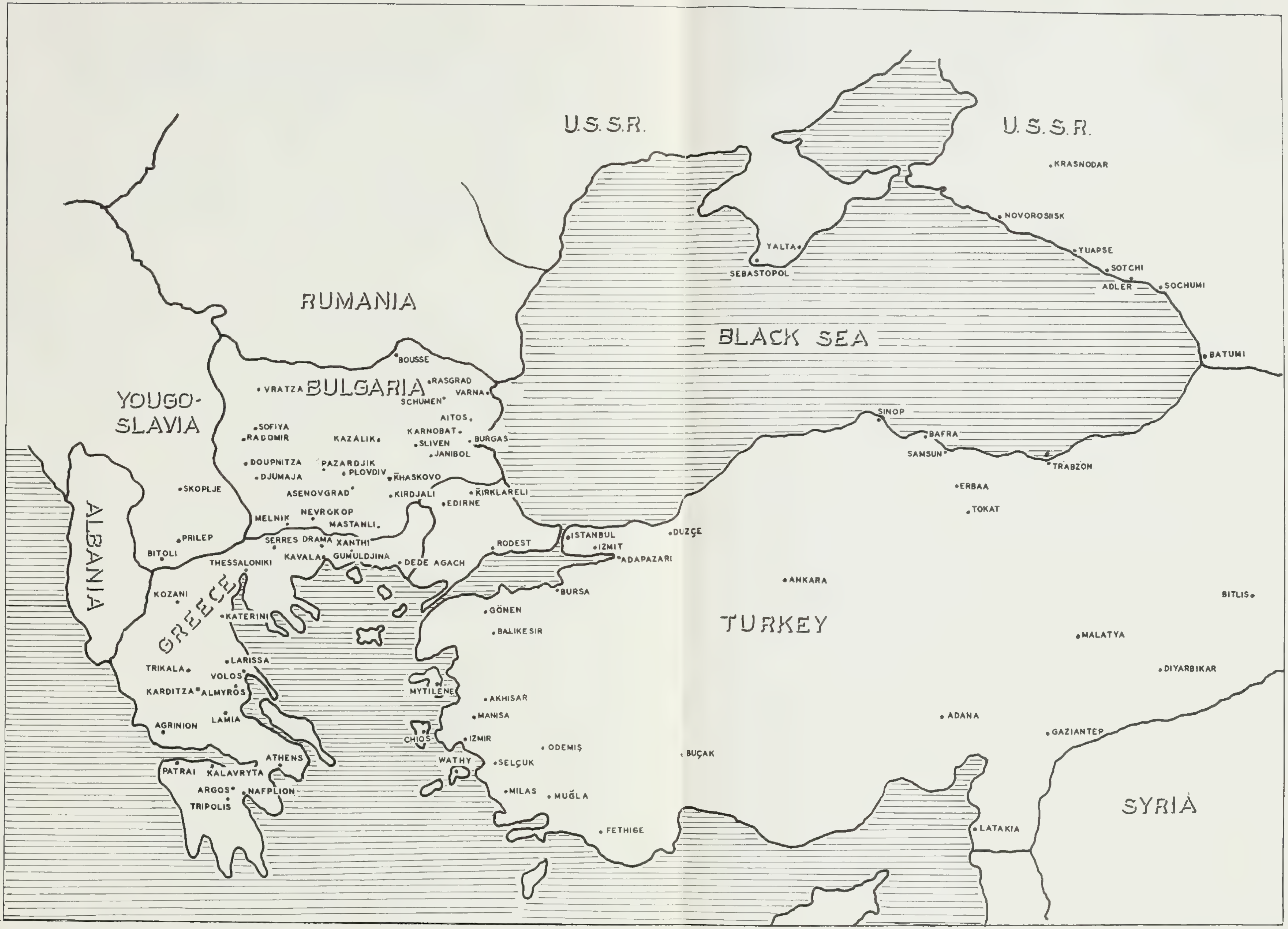

FIG. 124. Sites of some of the most important centers of production and marketing of aromatic tobaccos. The crop is transported to these centers from neighboring villages.

Sites of Manipulation and Storage Depots

Greece

Agrinion, Athinai (Athens), Drama, Karditsa, Kavala, Katerini, Kilkis, Komotini, Kos, Kozani, Mytiline, Nafplion, Serrai (Serres), Thessaloniki (Salonika), Trikala, Vathy, Volos, Xanthi.

Turkey

Adana, Adapazli, Akhisar, Alaçam, Bafra, Balikesir, Bandirma, Bitlis, Buçak, Bursa, Düzçe, Erbaa, Fethiye, Gemlik, Gerze, Gomec, Gönen, Hendek, Izmir, Izmit, Istanbul, Kirkaleri, Kula, Malatya, Manisa, Milas, Muğla, Odemiş, Reşan, Samsun, Sarköy, Selçuk, Sinop, Tire, Tokat, Tonya, Trabzon, Üzküdar, Yiğlika.

Bulgaria

Asenovgrad (Stanimaka), Burgas, Djumaja, Doupnitza, Khaskova, Kirdjali, Kochoukavak, Melnik, Nevrokop, Plovdiv (Philipopple), Sofia, Varna.

Yugoslavia

Bitola, Prilep, Skopje, Stroumitza.

U.S.S.R.

Adler, Batumi, Krasnodar, Maikop, Novorosiisk, Sebastopol, Sotchi, Sukhum, Tuapse.

European Tobacco Research Centers

Albania

The Mitchurin Institute at Tiranë.

Austria

The Station of Tobacco Breeding of the Austrian Monopoly at Fürstenfeld.

Belgium

The Station of Plant Improvement at Gembloux.

Bulgaria

The Institute of Plant Culture of the Academy of Science at Sofia, and Institute of Research on Tobacco at Plovdiv.

Czechoslovakia

The Tobacco Research Institute at Velky Bab.

France

The Experimental Tobacco Research Institute at Bergerac.

Germany

Bundesanstalt für Tabakforschung at Forchheim bei Karlsruhe.

Greece

The Tobacco Institute at Drama, with substations at Xanthi, Katerini, Karditsa, and Agrinion.

Holland

The Tobacco Department of the Institute of Horticulture at Wagenigen.

Hungary

Institute of Research on Tobacco at Budapest.

Italy

The Scientific Experimental Institute at Rome, with branches at Scafati, Verona, and Bonadi-Lecce.

Yugoslavia

Research Institutes at Prilep, Belgrad, Mostar, and Zagreb.

Poland

Experimental Tobacco Station at Skroniow.

Rumania

The Central Institute at Bucureşti-Baneasa.

Spain

The Institute for the Biology of Tobacco at Sevilla.

Switzerland

The Research and Orientation Center of the SOTA at Mont-Calme, near Lausanne.

Turkey

The Central Institute of Research on Tobacco at Cevizli-Maltipe, with substations at Samsun, Buça-Izmir, and Malatya.

U.S.S.R.

The Central Tobacco Institute at Krasnodar, with branches at Sukhum, Yalta, and Lagodechi and with the State Farm at Alma-Ata.

Glossary

Aromatic tobacco was first grown in the Near East in Turkey. Many of the words used in connection with this crop are Turkish and have been adopted in neighboring countries. Some of the more widely used terms and their meanings are given in the following list:

ak, white
ana, mother or main one
alti, six
akhisar, white fortress
armatha, string of tobacco leaves (Greek)
armathodema, *kalup* (Greek), leaves on strings in bales
aya, palm of the hand

bachi bağli, method of baling in which the bundles of leaves are placed in layers.
basma, press, also variety of Macedonian tobacco
bel, waist or middle

çapa, hoe
çarşamba, Wednesday, also variety of Turkish tobacco
çig, dew

damar, vein
dhefteromana, leaf grade of leaves below middle position
demet, hand of tobacco
denk, bale
dere, ravine or valley, also variety of Turkish tobacco
dil, tongue
dip, bottom or lower
djebel, crest of hill
duvan, tobacco (Bulgarian)

evkav, religious foundation, also variety of Turkish tobacco

fide, seedling

gradetmek, grading
gunes, sunshine
güzel koku, aroma

harman, mixture or blend
hendek, ditch, also variety of Turkish tobacco

ignelemek, stringing
imal, manipulation
inhisar, monopoly

kara, black
kabakulak, earless, referring to bare petiole
kaloup, method of baling in which leaves are left on the string
kefalodema, tied at head

kergef, trellis
koku, good
kovalama, intermediate, also kuvalama
köy, village
kir, field
küf, mildew
küfe, basket
kirinti, fragments or pieces
kulaksis, earless
kurak, dry
kurutlemek, curing

maden, metal, also variety of Turkish tobacco
mavra, dark or black
mahzen, magazine or storage depot

nemli, moist

oka, 2¾ pounds (Greek)
orta, middle
ödemiş, payment, kind of Izmir tobacco grown near city of same name
örgü, texture
ova, plains

pastal, bundle or bunch

renk, color

samsun, mastiff, also variety of Turkish tobacco
sari, yellow or blonde
sirdilli, also *siir-dili,* ox-tongue, referring to narrow leaves
sira, series or layer
stremma, 1000 square meters (Greek)

tekel, monopoly
tepe, top or tip
tohum, seed
tokat, slap, also variety of Turkish tobacco
tonga, loose-leaf method of baling
tombac or *tömbeki,* rustica tobacco
toplamak, harvesting or priming
tütün, tobacco
tütün kuruma, curing tobacco
tütün tile dizmek, stringing tobacco
tütün seçme, grading tobacco

üstü, upper
uç or *utch,* tip

yagnür, rain
yaprak, leaf
yastik, seedbed

xanthi, yellow (Greek)

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